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PAPER No. I.

PROBLEMS CONCERNING STORAGE OF CACAO ON THE GOLD COAST.

In the past it has not been a general custom to store cacao for very long periods on the Gold Coast. The aim of buyers has usually been to transfer stocks to Europe with the minimum of delay found possible. This tendency towards rapid shipment was dictated by a real fear that quality would deteriorate more quickly under the conditions of storage existing on the Coast than in warehouses in temperate climates.

There can be very little doubt that this fear was justified in the early days of the industry, when methods of preparation and drying were thoroughly inefficient and local methods of storage very primitive. Inadequately dried cacao would be sold by the farmer in small lots, retained by the small broker until lots of fair size could be made up, and finally held by the exporter until adequate shipments had been accumulated. Even in the last case provision for storage was not infrequently insufficient, and shipments were kept in the open or in badly protected or unventilated buildings.

There are two major sources of expenditure which accompany the system of storing in Europe and which would be avoided if stocks could be held on the Coast until finally sold to manufacturers. In the first place, handling from warehouses is doubled, since stocks have first to be stored on the Coast and then held in Europe until final sale. Secondly, there is in many cases unnecessary sea transport, since shipments eventually sold, say, to America, are distributed from Europe instead of being sent direct from the Coast. A third not inconsiderable item of avoidable expense is the higher cost of handling and storage in warehouses in Europe as compared with those on the Coast.

When the world's demand for cacao exceeded the supply, and sales were rapid and prices high, the disadvantages of the system were not as noticeable as they have now become. In many cases it must have been possible to effect sales while the produce was still in the Colony and so save the double handling, and, in any event, it was not so necessary to reduce costs. Nowadays, with supply in excess of demand, the position is very different, and every effort must be made to cut out all unnecessary expense.

The general opinion of the Department of Agriculture is that, with sound preparation and with storage accommodation comparable in efficiency with good warehouses in London or Liverpool, it should be possible to keep cacao for long periods in the Gold Coast without serious deterioration. A certain amount of information on the point is already available and, although final conclusions must be postponed until work now in hand on the question has been completed, it is of advantage to summarise present knowledge and indicate possible difficulties.

G. AUCHINLECK,
Director of Agriculture.

Commercial defects.

1. The commercial defects of local cacao are classed under five headings: mould, under-fermentation (slate-coloured interior), weevil and moth attack, germinated beans, and "other defects" (broken and undeveloped beans, presence of mucilage, placenta and foreign matter). The extent to which these occur is shown by the following table of inspection figures for total production during the past three years :—

Year.	No. of Samples Inspected.	Percentages of Defects Found.						Purity %
		Mould.	Slate.	Weevil.	Germ.	Other.	Total.	
1927	40,000	4.5	4.0	0.8	3.4	1.6	**14.3**	**85.7**
1928	85,356	3.3	4.4	0.6	2.5	0.4	**11.2**	**88.8**
1929	86,326	3.6	6.0	0.5	2.3	1.0	**13.4**	**86.6**

These defects practically all originate on the farm. They are easily avoidable, as may be seen by inspection of the following figures for lots prepared and sold by co-operative societies under Departmental supervision in 1929 :—

Tons made.	Mould.	Slate.	Weevil.	Germ.	Other.	Total.	Purity.
389⅓	0.6	1.1	0.1	0.8	0.7	**3.3**	**96.7**

At first thought it would be imagined that the only defects likely to cause increasing deterioration of quality during storage would be mould and weevil, but there is evidence of certain interlinkings between some of the defects mentioned above, and none of them can be regarded as free from the suspicion of causing progressive lessening of purity.

Interlinkings between defects.

2. Evidence on these suspected interlinkings between defects is not yet complete, or even certain, but they are mentioned here because work on some of

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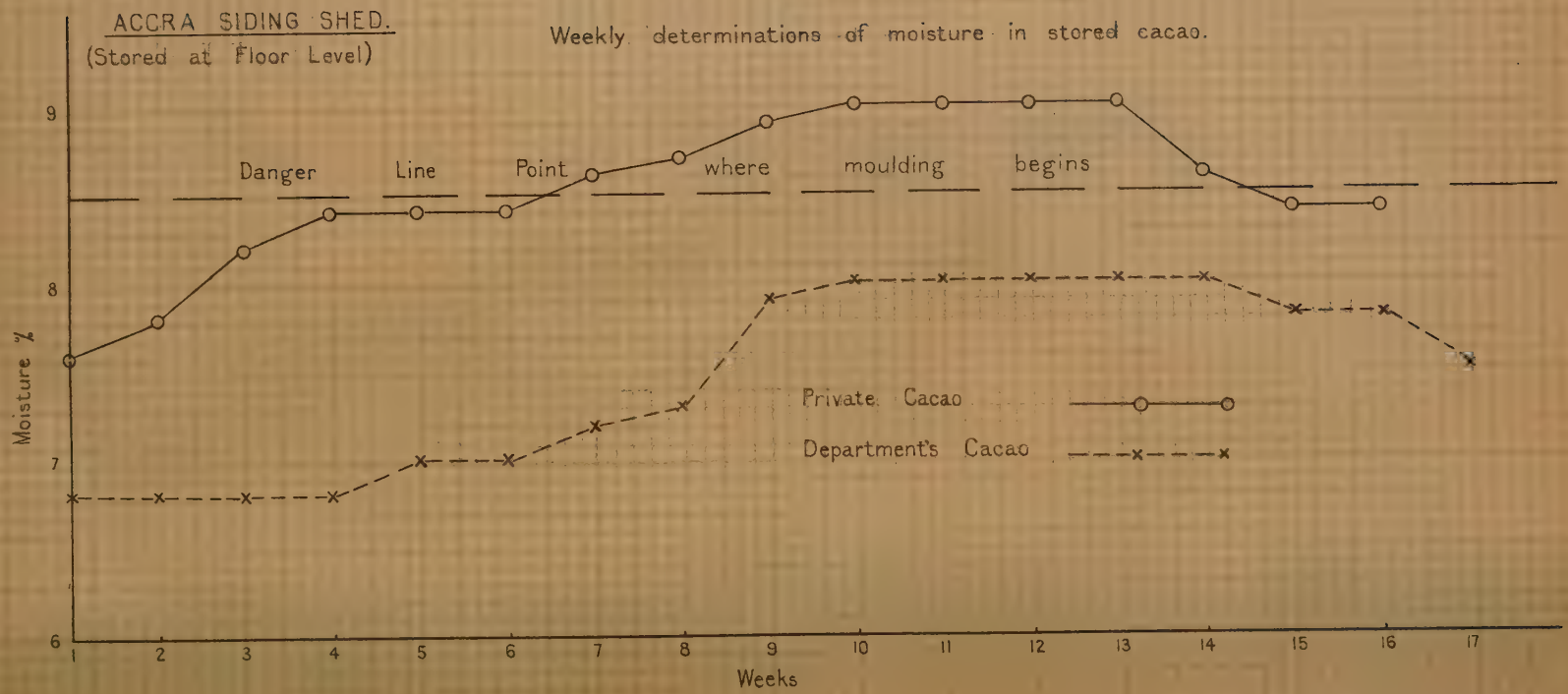


SURVEY H. Q. ACCRA. 1930.

them is in hand, while others seem too obviously likely to need confirmatory experiment. Broken beans and germinated beans (by which are meant beans the protective seed-coat of which has been ruptured by the growing germ) clearly afford easy access by moulds to the interior, although *H. A. Dade* has shown that some moulds can penetrate without these adventitious aids (pp. 87–90, Year-Book, 1928). In the case of undeveloped beans, the ratio of husk (seed-coat) to interior is far higher than in normal plumply filled beans, and it is known (pp. 83–86, Year-Book, 1928) that the seed-coat absorbs moisture to a far greater extent and more rapidly than does the interior. In consequence, it is reasonable to assume that undeveloped beans are in danger of becoming mouldy more readily than normal ones.

Suspected relation between weevil and moisture.

3. Up to 1928 it had always been assumed that weevil attack was purely a storage defect, but in that year *W. H. Patterson* obtained evidence locally that infestation frequently begins in the primitive drying trays used by farmers. This early infestation is, however, low in intensity, and prolonged storage is usually necessary before it reaches serious dimensions. Evidence from merchants indicates that cacao which has been damaged by damp or rain develops weevil far more rapidly than commercially dry cacao, and the Department has experiments in hand with cacao, to which have been added known amounts of water, to test this point. Certain figures of weevil-infestation obtained in Accra stores (by *H. L. Hill* and *A. N. de Heer*) are given below to show the rate at which the defect may increase :—

Period of Storage.	Shed No. 1.		Shed No. 2.			
			Ground Level.		Upper Levels.	
	Department Cacao. Weevil. %	Commercial Lot. Weevil. %	Department Cacao. Weevil. %	Commercial Lot. Weevil. %	Department Cacao. Weevil. %	Commercial Lot. Weevil. %
1 week ..	0.0	1.7	0.0	1.4	0.0	1.3
2 weeks ..	0.5	2.3	0.0	3.2	0.0	1.1
3 ,, ..	0.0	2.4	0.0	2.0	0.0	0.8
4 ,, ..	0.0	2.9	0.2	3.3	0.2	0.9
5 ,, ..	0.0	3.4	0.0	3.6	0.0	0.9

TABLE—*continued.*

Period of Storage.	Shed No. 1.		Shed No. 2.			
			Ground Level.		Upper Levels.	
	Department Cacao. Weevil. %	Commercial Lot. Weevil. %	Department Cacao. Weevil. %	Commercial Lot. Weevil. %	Department Cacao. Weevil. %	Commercial Lot. Weevil. %
6 weeks..	0.0	3.5	0.0	4.4	0.2	1.9
7 ,, ..	0.0	3.7	0.0	4.8	0.0	1.9
8 ,, ..	0.0	3.1	0.2	3.9	0.0	2.0
9 ,, ..	0.0	2.4	0.0	3.3	0.0	1.2
10 ,, ..	0.0	2.9	0.1	5.2	0.0	1.5
11 ,, ..	0.1	3.3	0.1	6.8	0.1	2.5
12 ,, ..	0.0	3.5	0.6	7.2	0.0	3.5
13 ,, ..	0.1	3.2	0.2	5.0	0.0	1.5
14 ,, ..	0.0	2.6	0.2	9.4	0.5	1.9
15 ,, ..	0.1	2.1	0.1	1.5	0.2	7.1
16 ,, ..	0.0	4.1	0.3	6.5	0.2	3.6
17 ,, ..	0.0	4.5	0.3	8.2	0.1	2.6
18 ,, ..	0.0	4.1	0.7	7.8	0.3	2.6
19 ,, ..	0.1	4 3	0.5	6.0	0.3	3 4

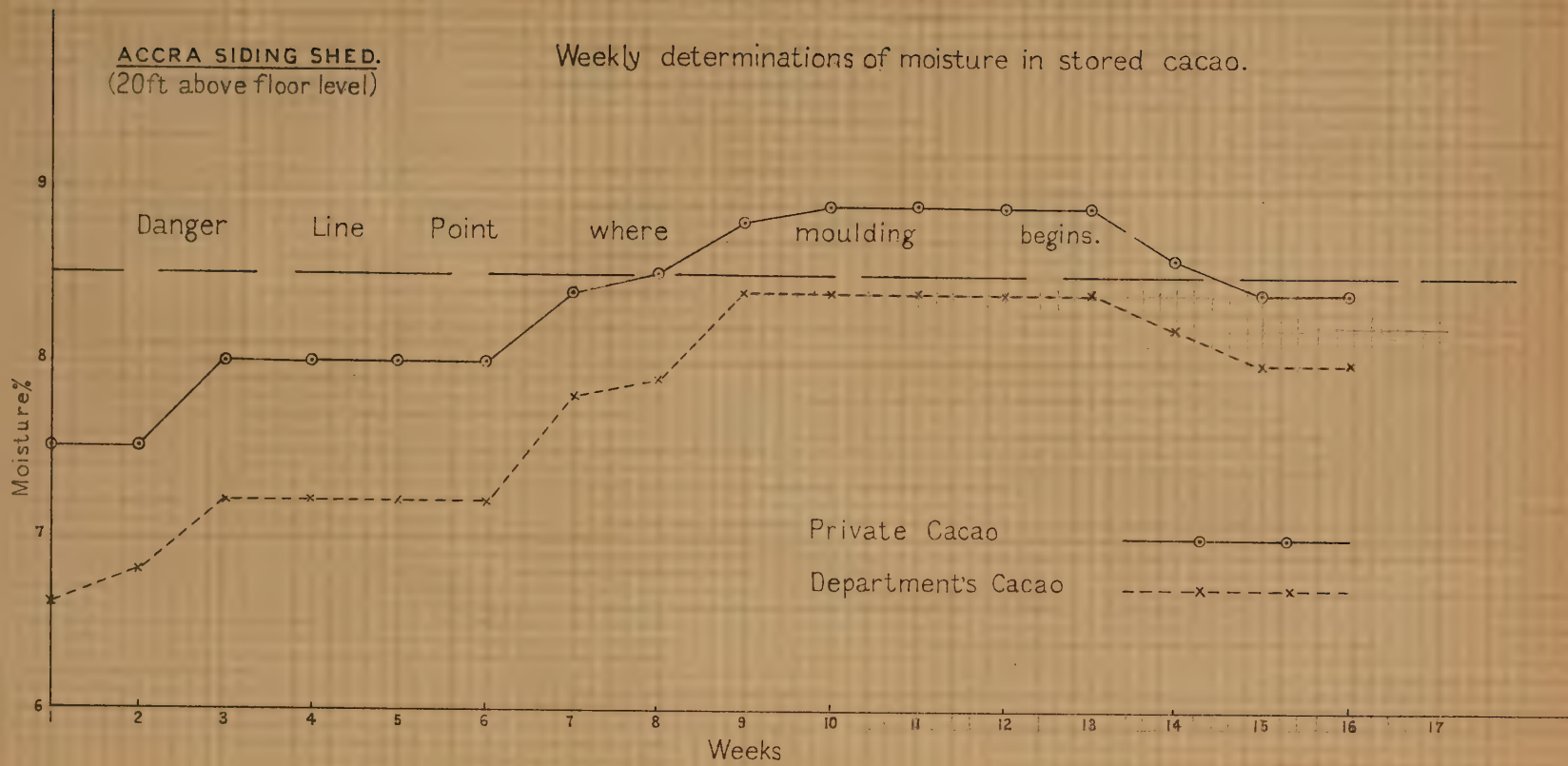
It is not possible yet to say whether the higher degree of infestation of the commercial samples above is due to their higher moisture-content or merely to the fact that they started with a higher percentage of weevil. The moisture, however, was considerably higher, rising from 7.1 to 8.4%, from 7.6 to 9%, and from 7.5 to 8.9% in the commercial lots, against from 6.2 to 7.6%, from 6.8 to 8%, from 6.6 to 8.4% for the three Department samples during the period storage. There is some indication in these figures that the lowest "optimum" point for weevil may be about the same as the "danger point" for mould (8.5% moisture).

Uncertainty regarding importance of slate.

4. Slate ranks high among defects, both in amount (paragraph 1 of this memo.) and as a criterion of quality in the world's markets. It is difficult to obtain consistent statements as to the reason for its importance. The colour passes on warming or when acidified (*R. H. Bunting*, p. 39, Year-Book, 1928), and so should not affect colour in manufacture.* The

* Since this was written verbal evidence has been given to the effect that cocoa powder made from slaty beans retains the undesirable colour and appears to have an unpalatable odour and flavour.

GRAPH No.II.



SURVEY H. Q. ACCRA, 1930

former notion that it indicated deficiency of "fat" in the bean is not correct. Recently the statement has been made by a manufacturer that cocoa-powder cannot be prepared from slaty beans, which if correct would explain the disfavour with which it is regarded. Recently the suggestion has been made that, in the course of port inspection locally, in freshly prepared cacao weevil appeared to be commoner in slaty than in normal beans, and from now onward a record is being kept at Accra port of the incidence of weevil on the two colours of beans (*H. L. Hill*). If the suspicion proves to be justified, further work will be done to ascertain whether slaty beans, which are always cheesy in texture, are consistently moister than well-fermented brown ones.

Moisture the chief factor.

5. In whatever direction we turn we find evidence of the overwhelming importance of moisture as a factor governing quality. Omitting the coarser and more obvious sources of moisture, such as wetting by rain or sea, we have to consider two sources, one due to improper drying by the farmer, the other due to absorption of moisture by the bean from the air. Both affect efficiency of storage, but while the former would be remediable by a system of Government inspection, the latter will probably prove to be avoidable only by devising special facilities in warehouses by which ventilation, and possibly disinfection, can be effectively carried out.

Initial moisture in farmers' cacao.

6. It is certain that up to the present it has been impossible to rely on the local farmer to dry his cacao uniformly and adequately. In 1928, 30 samples offered for sale by farmers at Aburi showed moistures ranging from 5.7 to 14% moisture, with a mean of 8.1%, and 34 samples from Winneba, Saltpond, Sekondi, Kumasi and Koforidua showed moistures ranging from 5.6% to 10.9%, 19 being over 8% and 5 over 9½% (*J. L. Scott*, pp. 61 and 62, Year-Book, 1928). The mean of several commercial samples entering Takoradi cacao sheds in 1929 was found to be 7.9% (*B. T. Steemson*), and during recent work in Accra commercial samples were found to range from 7.1 to 7.6%. That these percentages are unnecessarily high is shown by the figures for cacao from Experiment Stations of the Department, which were 6.2, 6.5, 6.6 and 6.8%. The Department uses no artificial means of drying, relying merely on the sun and on regular stirring and spreading.

Danger point of moisture.

7. In 1928 it was shown by *H. A. Dade* that internal moulding occurred in beans the moisture-content of which was 9.5%, but not in those whose moisture was 8% (p. 86, Year-Book, 1928). *R. H. Bunting* (on pp. 55 to 57 of Year-Book, 1928) shows that two moulds locally can occur in beans recognised to be commercially dry, but the percentage of moisture present is not given. Up to the present no statement has been made, on the Department's certificates of quality, of the moisture-content, since inspection has been limited practically entirely to ports, and the cacao examined has therefore had the opportunity of being dried by the exporting firms. When inspection has been changed from the ports to up-country centres, it will be absolutely necessary to determine the moisture on all lots inspected. Without the figure there will be no guide as to the degree of safety with which the lot may be stored, and certificates will be valid only for the day of issue. Necessary apparatus for determining moisture has been ordered by the Department. It is probable that merchants would be wise to penalise in price any lots showing moistures above 7%. At the very least the penalty should be equal to the cost of re-drying.

Absorption of moisture by the bean.

8. The term "Relative Humidity of Air" should be understood clearly, since it is by this factor that the efficiency of a cacao store will be judged. Air always contains water vapour, and the maximum amount it can hold differs with the temperature. The following table (from p. 288, *N. P. Chamney* in Year-Book, 1928) gives the amounts of moisture at ordinary temperature ranges :—

Temperature of Air in Degrees Fahrenheit.	Maximum Weight of Vapour the Air can hold (in Grams per Cubic Metre).
59.0	12.8
68.0	17.2
77.0	22.9
86.0	30.1

When the air has its maximum amount of moisture at a particular temperature (for example, 22.9 grams at 77 degrees) its relative humidity is said to be 100. Less amounts can then be expressed as percentages; for example, air holding 25 grams of moisture at 86 degrees is said to have a relative humidity of $\frac{25}{30.1} \times 100 = 83\%$.

J. L. Scott, working under laboratory conditions and fixing the relative humidity of his artificial atmo-

spheres, found that cacao absorbed moisture at the following rates (Paper No. IX, Year-Book, 1928).

Days Exposure to Atmosphere.	Percentage of Moisture in Cacao when Relative Humidity was				
	75%	80%	85%	90%	95%
At start	6.2	6.2	6.2	6.2	6.2
After					
1 day	6.7	7.0	7.6	9.2	10.6
2 days	6.9	7.4	8.1	10.2	12.3
3 ,,	7.1	7.6	8.4	10.9	13.6
4 ,,	7.2	7.7	8.5	11.2	14.4
5 ,,	7.3	remained constant at 7.7	8.6	11.4	15.1
6 ,,	remained constant at 7.3		8.7	11.6	15.3
7 ,,			remained constant at 8.7	remained constant at 11.6	remained constant at 15.3
8 ,,					
9 ,,					

The rate of absorption would naturally be less rapid when the beans are in large bulk in bags. The figures above show the rate under conditions of maximum exposure to the atmosphere. Beans in bags would take longer to rise to these figures, but it is only a question of difference in time, and the final percentages attained would be the same as those above.

Relative humidity of air in the open, ports.

9. The relative humidity of the open air varies very considerably at different points in the Gold Coast, and, as the atmosphere inside a store bears some relation to that outside, the figures below indicate the suitability of various towns for storage.

RELATIVE HUMIDITIES OF OUTSIDE AIR, 9 A.M.

Towns.	October to March.		April to September.		Year's Means.
	Highest and Lowest Month's Average.	Mean.	Highest and Lowest Month's Average.	Mean.	
Ports.					
Accra ..	67.2 to 72.6	**70.4**	72.3 to 78.8	**75.8**	**73.4**
Ada ..	79.1 to 82.5	**81.5**	80.2 to 85.8	**82.8**	**82.2**
Cape Coast ..	74.0 to 80.1	**77.5**	77.0 to 86.0	**81.7**	**79.7**
Keta ..	70.2 to 74.9	**71.8**	71.9 to 74.3	**72.7**	**72.1**
Saltpond ..	75.2 to 80.8	**78.6**	79.9 to 85.4	**82.5**	**80.6**
Sekondi ..	77.5 to 83.2	**80.6**	76.0 to 85.0	**80.7**	**80.7**
Winneba ..	77.7 to 83.5	**79.4**	79.0 to 88.0	**84.8**	**82.1**

The eighth port, Axim, does not ship cacao in any quantity at the moment, but may become more important as the Western Province develops. It is quite unsuitable as a storage centre, relative humidities being consistently high. Its figures are 84 to 90.9 (mean, 87.4) for the period October to March, 86.2 to 91.7 (mean, 88.6) for April to September, and an annual mean of 88. The Department of Agriculture does not find it possible, for example, to store copra there without deterioration.

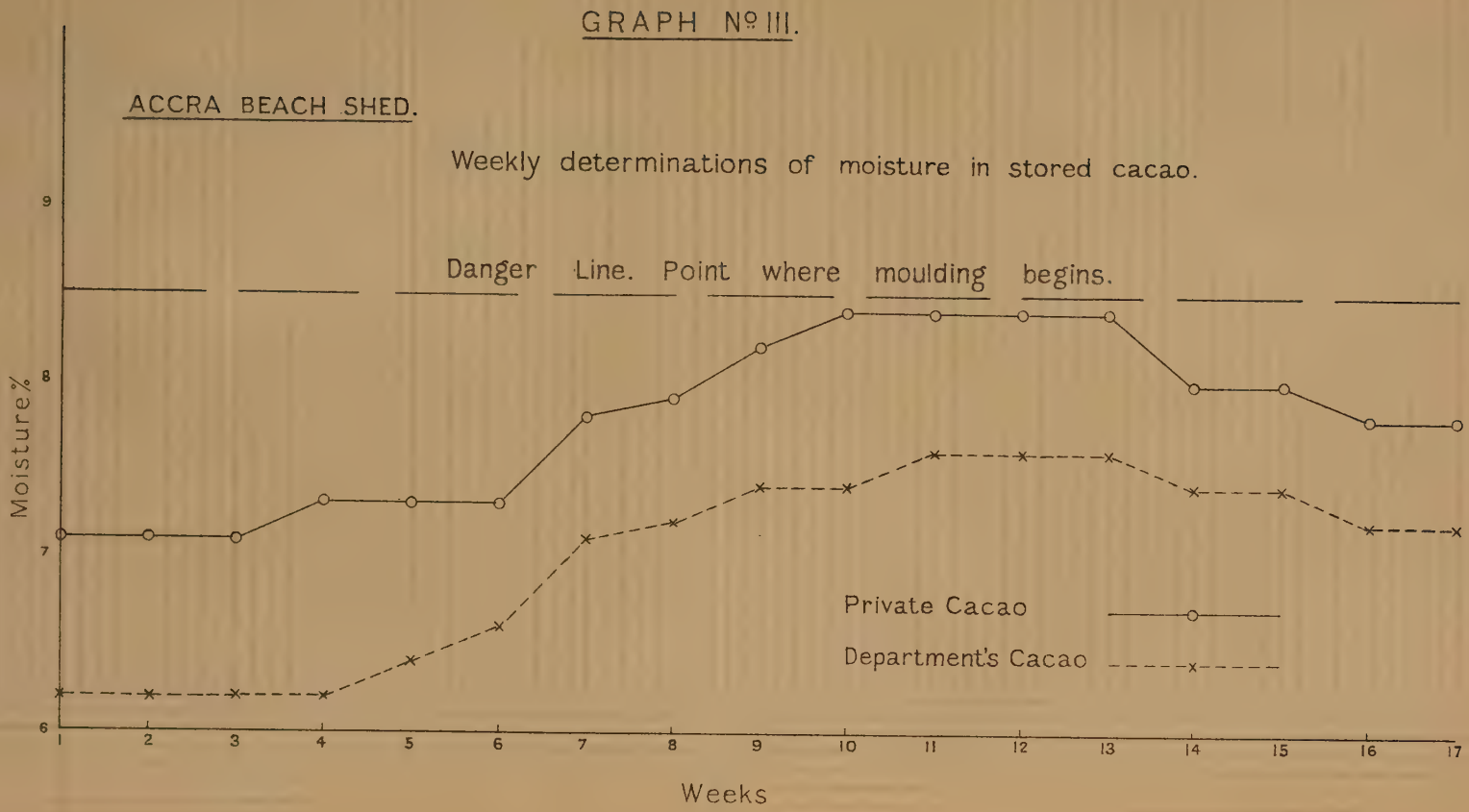
Significance of port humidities.

10. The air within a store-shed is invariably drier than the surrounding open air, as will be seen from figures in later sections of this report. This fact, taken in conjunction with figures in the above table and with the knowledge that relative humidities have to be about 85% for comparatively long periods (table in paragraph 8 above) before the moisture-content of cacao rises above the danger-point of 8½%, leads to the conclusion that the seven ports are above suspicion as suitable storage centres. In addition, it is obvious that cacao in bags stored in bulk absorbs moisture less readily than in the laboratory conditions under which the table in paragraph 8 was obtained. Sheds at the seven ports, even without extra arrangements for special ventilation, should preserve well-dried cacao for lengthy periods without deterioration in quality. On the other hand, it must be kept in mind that the air-humidity readings recorded above were taken at 9 a.m., and night humidities are no doubt very much higher. Further observations are needed, but evidence so far indicates that efficient storage is quite possible at the ports.

Relative humidities of air in the open, up-country.

11. The position is different in the cases of centres up-country, which are or might be used as points for storage. The figures of nine centres for which information is available are given in the table on p. 13.

This table shows that only the stations north of the scarp (Sunyani and Kintampo) offer favourable conditions for cacao storage. The other seven stations cover the areas in which lie the great cacao-buying centres of the Coast, including all which handle more than 500 tons and over (*G. G. Auchinleck* and *N. P. Chamney*, Paper VI, Year-Book, 1928). The rainfall maps published by the Department of Agriculture show that Akrokerri, Anyinam, Bekwai, Bomfa, Dunkwa, Ejisu, Juaso, Koforidua, Konongo, Kumasi, Mangoase, Nkawkaw, Nsawam, Pakro and Tafo, railway centres hand-



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RELATIVE HUMIDITIES OF OUTSIDE AIR, 9 A.M.

Towns.	October to March.		April to September.		Year's Means.
	Highest and Lowest Month's Average.	Mean.	Highest and Lowest Month's Average.	Mean.	
Up-country.					
Aburi ..	78.2 to 87.5	**84.0**	83.8 to 90.7	**87.8**	**85.7**
Akuse ..	65.9 to 75.8	**71.6**	69.7 to 76.2	**72.8**	**72.5**
Asuassi ..	82.2 to 87.6	**85.1**	80.3 to 88.5	**85.9**	**86.0**
Begoro ..	76.5 to 83.4	**79.5**	79.1 to 87.4	**84.5**	**82.2**
Ho	80.0 to 88.5	**84.7**	86.8 to 90.3	**88.8**	**86.8**
Kintampo ..	56.8 to 74.8	**67.4**	68.2 to 79.6	**75.0**	**71.2**
Kumasi ..	78.7 to 88.3	**83.7**	79.6 to 87.7	**84.1**	**84.2**
Sunyani ..	69.9 to 81.8	**76.8**	74.3 to 84.4	**80.3**	**79.6**
Tarkwa ..	81.8 to 89.5	**86.1**	81.8 to 87.9	**84.7**	**85.4**

ling from 1,000 to 30,000 tons annually, lie in this area, as do also Asamankese, Oda, Suhum and Swedru, the great collecting centres for lorry transport to the coast. It is obvious that if any of these towns and stations be used for storage, very special attention would have to be given to the construction and ventilation of stores. None of them is safe for long storage in ordinary sheds or stores.

Interval between harvest and export.

12. The average interval which elapsed between harvesting and export was 79 days in the 6 seasons 1922–23 to 1927–28 (*J. D. Broatch*, Paper No. IX, of this Year-Book). With improving facilities for transport the interval has gradually lessened, having fallen from 87 days average in the three seasons 1922–25 to 70 days in 1925–28. Actual preparation of the bean does not take more than 3 to 4 weeks at a maximum (7 days for fermenting and from 7 to 14 days for drying), so that an average period of one to two months elapses between drying and shipment. The period is spent in two or three sales (itinerant buyer, broker and merchant), in bulking, re-drying, bagging and transport, and, until the produce reaches the merchant, storage conditions are frequently bad. With the organisation of co-operative societies and with standardisation of quality by inspection, centralisation at ports should be far more rapid, since the merchants will be able to make up his shipments direct from the farmer on the basis of quality certificates. Apart from the savings of costs thus effected, there will be less storage under improper conditions up-country.

Air moisture inside and outside of sheds, Takoradi (Graph IV).

13. During November and December, 1929, and January, 1930, a thorough examination of a store at Takoradi was carried out. Moisture readings were taken at three points inside of the shed and one point outside, each point being observed six times daily (8 a.m., noon, 4 p.m., 8 p.m., midnight and 4 a.m.). In all, 1,128 observations were made (*B. T. Steemson*, Paper No. V of this Year-Book), with the following results :—

RELATIVE HUMIDITIES (6 DAILY READINGS).

	Inside open shed.			Outside shed.
	Floor level.	13 feet above.	25 feet above.	
November ...	(144 readings) 77.6	(84 readings) 80.3	(150 readings) 80.3	(54 readings) 81.5
December ...	(174 readings) 70.4	(174 readings) 81.7	(174 readings) 80.3	(174 readings) 85.3
January ...	(78 readings) 79.3	(78 readings) 82.2	(78 readings) 81.3	(78 readings) 87.7

The dryness of the air at floor level owing to ventilation through the shed doors is very marked. The changes in moisture-content shown during this period by three lots of 10 bags each of cacao from the Kumasi Station of the Department of Agriculture are shown in Graph IV attached to this paper. The defects in the three lots at beginning and end of the 11 weeks of storage were as follows :—

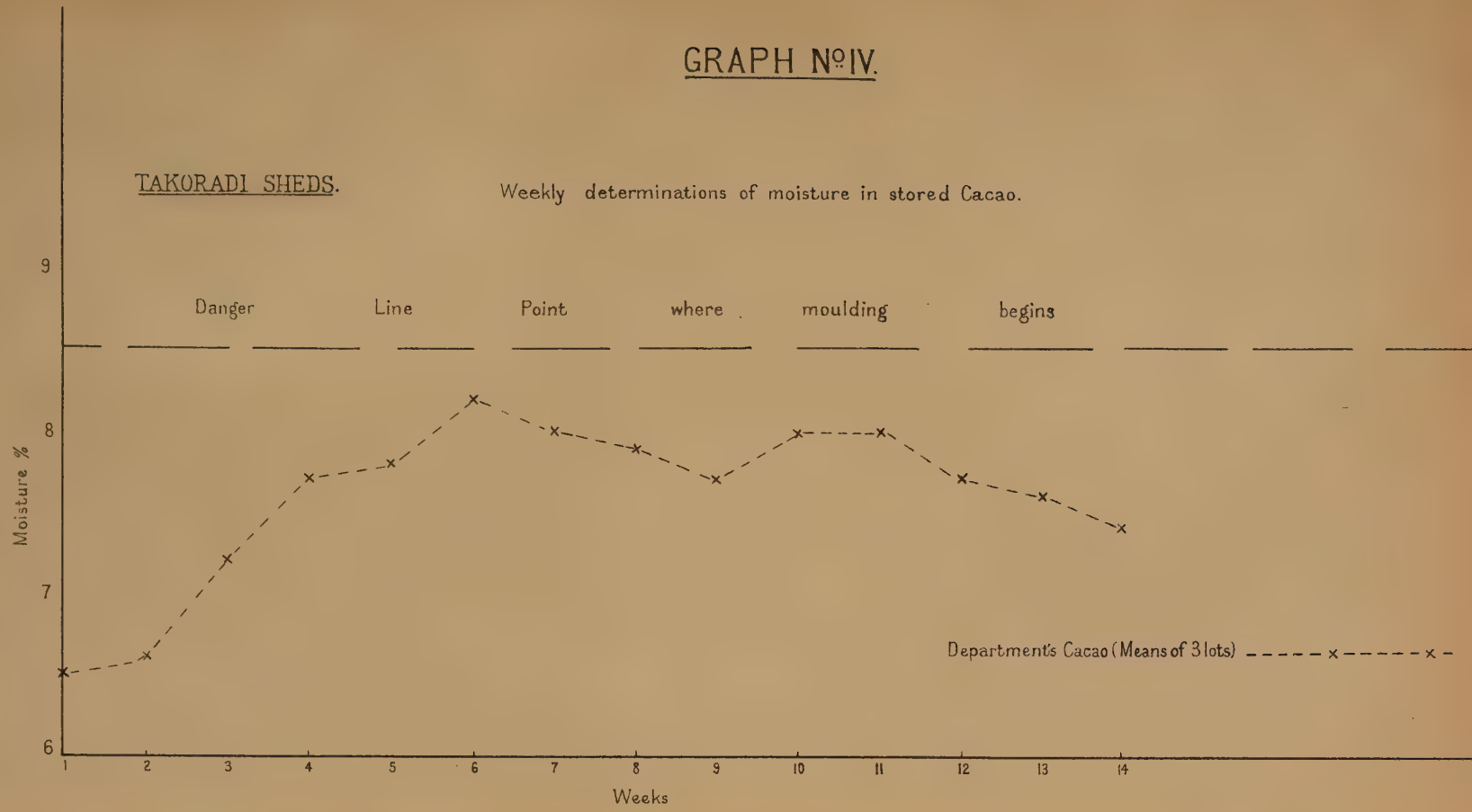
	Mould.	Weevil.	Germ.	Slate.	Other.	Purity.
Lot 1.						
1st week ..	0.5	0.0	0.0	0.0	1.0	**98.5**
11th ,, ..	0.9	0.0	0.0	0.0	0.4	**98.7**
Lot 2.						
1st ,, ..	0.8	0.0	0.1	0.0	0.8	**98.3**
11th ,, ..	0.9	0.0	0.0	0.0	0.4	**98.7**
Lot 3.						
1st ,, ..	1.2	0.0	1.1	0.0	0.6	**97.4**
11th ,, ..	0.4	0.0	0.0	0.0	1.2	**98.4**

For some three months, plus the period necessary for preparation and transfer from Kumasi, storage did not cause deterioration of quality.

Storage in the open, Accra.

14. In July, 1930, a shipment was made up of two lots, one of which had been stored in an Accra warehouse while the other had been kept under tarpaulins on beach. There had until then been some popular doubt as to the effect of storing in the open air, so it was decided to sample the two lots separately. Results were as follows :—

GRAPH No. IV.



SURVEY, H. Q. ACCRA.

Storage.	Number of Samples Drawn.	Mean of Samples Mould. %	Weevil. %
Warehouse ..	84	2.9	2.5
On beach ..	20	7.5	4.6

These results confirm the view that storage under tarpaulins in the open is unsafe.

Mould in Accra stores.

15. Weekly examinations of cacao have been made by *H. L. Hill* and *A. N. de Heer* from April to July in two storage sheds in Accra, and the figures for mould are given in the following table :—

Weeks of Storage.	Percentage of Mould Found in Lots.					
	Beach Shed.		Siding Shed.			
			At Floor.		At Top.	
	Department Cacao.	Commercial Lot.	Department Cacao.	Commercial Lot.	Department Cacao.	Commercial Lot.
Start ..	0.0	2.4	0.2	4.4	1.0	9.2
1 week ..	0.8	3.5	0.2	7.6	0.5	6.6
2 weeks ..	0.2	2.8	1.2	6.6	0.0	8.6
3 ,, ..	0.0	3.9	0.2	8.4	0.2	4.6
4 ,, ..	0.0	3.2	0.0	6.6	0.0	10.8
5 ,, ..	0.0	1.0	0.0	10.5	0.5	12.6
6 ,, ..	0.2	6.7	0.0	9.7	0.5	13.3
7 ,, ..	0.2	5.9	0.0	2.3	0.2	13.1
8 ,, ..	0.1	1.8	0.3	2.8	0.2	4.0
9 ,, ..	0.3	1.5	0.3	3.2	0.2	6.5
10 ,, ..	0.2	1.9	0.4	12.7	0.7	19.3
11 ,, ..	0.3	7.3	7.4	14.4	0.2	7.9
12 ,, ..	0.6	13.2	4.0	2.8	0.4	6.0
13 ,, ..	0.2	4.3	2.3	4.3	2.5	6.9
14 ,, ..	0.3	5.2	4.1	10.5	2.8	13.8
15 ,, ..	0.6	5.4	1.7	6.6	9.5	22.0
16 ,, ..	0.4	4.3	1.8	3.2	1.3	8.3
17 ,, ..	0.2	3.4	4.8	3.7	2.8	11.7
18 ,, ..	0.1	4.2	4.0	5.1	9.3	13.2

The beach shed is clearly more efficient, and sound Department cacao deteriorated imperceptibly during 15 weeks' storage. The siding shed gave poor results and is not efficient for storage for periods of more than two months in the case of sound cacao. Neither shed is suitable for storing defective cacao, or, to put it in another way, neither shed dries damp cacao sufficiently rapidly to avoid moulding.

Moisture in cacao in Accra sheds (Graphs I., II and III).

16. Graphs I, II and III attached depict the changes in moisture of the cacao described in paragraph 15. In these graphs the "danger point" has been assumed to be 8.5%, a figure which is probably too high for safety. With special ventilation it should be possible to keep moisture below 8%. Graphs I and II show that the moulding in the siding shed progresses with increase of moisture in the beans, both commercial samples having risen above 8.5% moisture. The figures on which the graphs are based are tabulated for reference.

MOISTURE PER CENT. CACAO BEANS.

	Beach Shed.		Floor, Siding Shed.		Top, Siding Shed.	
	Department.	Commercial.	Department.	Commercial.	Department.	Commercial.
2nd week	6.2	7.1	6.8	7.6	6.6	7.5
3rd ,,	6.2	7.1	6.8	7.8	6.8	7.5
4th ,,	6.2	7.1	6.8	8.2	7.2	8.0
5th ,,	6.2	7.3	6.8	8.4	7.2	8.0
6th ,,	6.4	7.3	7.0	8.4	7.2	8.0
7th ,,	6.6	7.3	7.0	8.4	7.2	8.0
8th ,,	7.1	7.8	7.2	8.6	7.8	8.4
9th ,,	7.2	7.9	7.3	8.7	7.9	8.5
10th ,,	7.4	8.2	7.9	8.9	8.4	8.8
11th ,,	7.4	8.4	8.0	9.0	8.4	8.9
12th ,,	7.6	8.4	8.0	9.0	8.4	8.9
13th ,,	7.6	8.4	8.0	9.0	8.4	8.9
14th ,,	7.6	8.4	8.0	9.0	8.4	8.9
15th ,,	7.4	8.0	8.0	8.6	8.2	8.6
16th ,,	7.4	8.0	7.8	8.4	8.0	8.4
17th ,,	7.2	7.8	7.8	8.4	8.0	8.4
18th ,,	7.2	7.8	7.6	8.0	7.8	8.2

Effect of drying on absorptive power.

17. A point of considerable importance shown in Graphs I, II and III is that, even after 14 weeks, the moisture in well-dried cacao does not rise as high as that in damp cacao. The curves for the two do not meet. A likely explanation of this is that some substance is partially destroyed by drying (say to 7% or below), which before drying had the power of absorbing moisture from the air. Previous indication that this is the case had been obtained in the course of work on rate of moisture absorption (*J. L. Scott*, Year-Book, 1928, Paper IX). The point is best illustrated by the following tables :—

	Percentage of Moisture in Beans at Equilibrium with Atmosphere when Atmosphere is at Relative Humidity.			
	75%	80%	85%	90%
Beans dry at start allowed to absorb rose to	7.3	7.7	8.7	11.6
Beans wet at start allowed to dry rose to	7.0	8.5	10.5	11.8

In theory, the two sets of figures should be the same, that is a sample if dried and then allowed to remain in air of fixed humidity should in the end have the same moisture as the sample has if wetted and allowed to dry out in air of the same humidity. Evidence is not yet definite, but the point is important, and planned trials will be carried out to obtain exact information. It is not unlikely that mucilage on the outside and inside of the bean loses some or all of its hygroscopic (absorptive) power if dried. If the view be correct, thoroughly dried beans may possibly remain perpetually below the danger-point even in inefficiently ventilated stores.

Summary.

(*a*) The atmosphere at up-country centres in the Gold Coast is too damp to permit of long storage of cacao without deterioration in quality.

(*b*) At ports of the Gold Coast air humidity is dry enough to allow of storage of well-prepared cacao for periods up to 15 weeks without increase of weevil or mould.

(*c*) Too long an interval usually elapses between harvesting the crop and bringing the produce to ports (about 70 to 80 days), and this period can be shortened by cutting out intermediate sales and avoiding bulking, re-drying and re-bagging.

(*d*) Storage under tarpaulins in the open is not safe.

(*e*) Excess moisture in the bean is the controlling factor in moulding, almost certainly in weevil attack, and possibly is increased by the presence of undeveloped and slaty beans.

(*f*) The farmer cannot be relied on to dry his produce thoroughly, and Departmental certificates issued up-country should give the percentage of moisture in all lots inspected.

(*g*) Ventilation in cacao stores at ports needs special care and attention, and possibly forced draught may be advisable.

(*h*) Cacao may lose its power of absorbing water from the air if it is dried thoroughly after fermenting, and the point is being investigated.

(*i*) Figures for relative humidity inside and outside of produce stores in Liverpool and London and elsewhere in temperate countries are needed for comparison with Gold Coast figures.

PAPER No. II.

THE CO-OPERATIVE MOVEMENT IN THE GOLD COAST IN 1929.

By A. W. PATERSON.

In Paper IV of the 1928 Year-Book the writer dealt with the possibilities and probable application of the co-operative movement to local needs, and since then has been afforded an opportunity of studying the movement in Ceylon and India and was able to discuss the problems being tackled there with numerous co-operators of wide experience. A report of the observations made during this trip was published as Bulletin 17 —"Studies in Co-operation in India and Ceylon"—but that report dealt purely with what the writer saw in these countries. Now it is desired to examine what has been done locally and how far it will be possible to apply co-operative principles to the solution of the local problems.

Origin.

The subject of rural finance on the Gold Coast was brought into prominence in 1925 by a number of African gentlemen in Accra submitting a proposal to Government for the establishment of an Agricultural Bank. The Director of Agriculture at a general meeting of the now defunct Gold Coast Agricultural and Commercial Society, to which the whole scheme was submitted by Government for consideration, made a counter-proposal for the establishment of a system of co-operative societies as in existence in Ceylon and India. This scheme was eventually accepted by the local Government after a good deal of discussion, and a "Draft Ordinance to regulate the constitution of Co-operative Societies, to control their operations and prescribe the liabilities of their members," based on the Ceylon Co-operative Societies Ordinance No. 34 of 1921, was introduced into the Legislative Council in May, 1929, and read for the first time.

Need for legislation.

That there is need for special legislation if the Government intends to encourage the development of the co-operative movement there can be no doubt

whatever, as otherwise any company, association or partnership of 20 members or over, banding themselves together for any purpose, must be registered under and comply with the 167 sections of the Companies Ordinance (Cap. 25). The elaborate provisions of that statute, however necessary in the case of combinations of capital on a large scale, are wholly unsuited to societies of the kind it is desired to encourage.

Indian legislation.

India was the first tropical country in the Empire with a large illiterate native population to introduce special legislation of this type, and Sir D. Ibbetson's speech, when he introduced what afterwards became the Co-operative Credit Societies Act of 1904, has become a classic, and the following extracts from that speech clearly explain the purpose and intention of such legislation :—

> The first thing to be done, therefore, was to take such societies out of the operation of the general law on the subject and to substitute provisions specially adapted to their constitution and objects. In the second place, it was desirable to confer upon them special privileges and facilities, in order to encourage their formation and assist their operations. And, thirdly, since they were to enjoy exemption from the general law and facilities of a very special nature, it was very necessary to take such precautions as might be needed in order to prevent speculators and capitalists from availing themselves, under colourable pretexts, of privileges which were not intended for them. These three ends were the objects which we kept in view in framing the legislation that I am about to propose.
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> * * * *
>
> Certain broad principles must be laid down, and certain precautions must be insisted upon ; but within those principles and subject to those precautions, the people must in the main be left to work out their own salvation on their own lines, the function of Government being confined to hearty sympathy, assistance and advice.

Discussion locally.

The Gold Coast draft Ordinance, as has already been stated, is based on that of Ceylon, which, in its turn, was based on the co-operative legislation of India. There are few essential differences between the India Act and the Ceylon Ordinance, because both were designed for dealing with Eastern peoples, but in accepting Ceylon as a basis for Gold Coast legislation some points of difference must be expected. Local customs, etc., must be taken into consideration, and

this was the reason for delaying the second reading of the local draft Co-operative Ordinance. The local Chambers of Commerce were all asked to submit their views and any objections they had to its provisions, etc. The Provincial Councils of Chiefs have considered the proposed legislation and given the benefit of their criticism. Moreover, the draft Ordinance has been reviewed by the Agricultural Adviser to the Secretary of State for the Colonies, the criticisms of Mr. Stockdale being particularly valuable as he was responsible for the Ceylon co-operative legislation and had a long experience as Registrar of Co-operative Societies in that colony. The draft Ordinance was also sent to the Horace Plunkett Foundation for the benefit of their experience, and some very valuable suggestions were made.

Horace Plunkett Foundation.

As would be expected, the points raised by the Horace Plunkett Foundation were generally technical ones concerning co-operation, whilst many of the local criticisms received were due to misunderstandings rather than to any real objection to the provisions of the Bill. There are only two main provisions of the draft Ordinance which it has been found necessary to alter seriously in order to make it conform to local customs and conditions.

Land problems.

The first of these is that in India and Ceylon there is individual ownership of land, with definite titles that are officially registered, whereas locally the land is generally communally owned and there is practically no land registry. Thus it has been found necessary to alter the conditions necessary for membership of a society from "reside or own landed property within its proposed area of operation" to "reside or occupy land within its proposed area of operations." To have retained the Eastern wording would no doubt have been the cause of endless trouble and litigation, as the present system of land tenure is undergoing metamorphosis, and unscrupulous persons might have endeavoured to use this Ordinance to establish title to land which is in dispute. The West African land policy demanded amendment to this section, and by substituting occupation for ownership the difficulty has been overcome.

Inheritance.

The India Act enacted, in order to overcome certain difficulties in connection with the local laws of inheritance, that each member of a co-operative society should nominate one person to succeed to his share or

interest in the society on his death. The idea behind this enactment was twofold: firstly, to avoid any danger of the society being tangled up in litigation concerning succession; and, secondly, so that any share or interest in a society could be retained in the society by transferring the shares to the successor if he was a member or could become a member; and, failing that, to pay the value of the deceased's share or interest to the nominated person. The Gold Coast laws of inheritance differ from those in the East, and it has been found necessary to amend the section dealing with this subject in order to make it fit in with local customs. Amongst the Akan people succession is by the female line, the usual heir being the elder nephew, whilst the non-Akan tribes have direct succession. The West African is still rather primitive in many of his ways, and displays at times some traits in his character which show that he still suspects even his own family of treachery. None of the tribes will agree to the nomination of a successor whilst the nominator is alive, in case the nominee should desire to become the owner of the estate prematurely. To overcome this the society is empowered to transfer the share or interest of a deceased member to the person who is proved to the satisfaction of the Committee to be the heir of the deceased or the representative of his family under a will or in accordance with the local tribal customary law on inheritance.

Priority of claim.

Another important alteration that is suggested is with regard to the priority of claim of a registered society against the crops or other agricultural produce raised, cattle, agricultural or industrial implements, raw materials for manufacture or business premises of any member, obtained in whole or part by means of a loan from the society. It is proposed to make the claim of the registered society on these subjects a first charge after the claims of Government on the property of its debtors and of lessors in respect of rent or any money recoverable as rent. This is on the lines of the Bombay Co-operative Societies Act of 1925, and this provision replaces what was merely a prior claim as in the Indian Act of 1912 and the Ceylon Co-operative Societies Ordinance, 1921. A provision is inserted, however, that nothing in this clause shall affect the claims of any *bona-fide* purchaser or transferee for value without notice.

Registrar's functions.

The main criticism levelled at the draft Ordinance locally has been that it provides for too much Govern-

ment control. This is a misunderstanding, and no doubt arises through the wide powers given to the Registrar, whose functions have not been grasped by these critics. The use of the term "Registrar" is perhaps an unfortunate choice of a title, as it generally implies one who merely registers and records documents, whereas the Registrar of Co-operative Societies has much wider responsibilities. The actual duties of the Registrar are to encourage the formation and to foster and guide the growth of the co-operative movement generally. He is entrusted with the statutory duties of registration, audit and liquidation of societies.

Registration.

The actual duty of registration demands more than the mere signing of a certificate of registration for a society that has complied with certain conditions laid down in the Ordinance. The Registrar must satisfy himself that the society desiring registration is co-operative in intention as well as in name, and that it is not endeavouring to obtain the privileges offered to co-operative societies for other than co-operative purposes. The Ceylon Ordinance lays down that the Registrar "shall register," whereas the Indian Act states "may, if he thinks fit, register." The Indian wording is undoubtedly preferable from the point of view of the practical operation of the Ordinance, as the Registrar ought to have the right to withhold registration if he thinks fit, and it has been found necessary in practice elsewhere to withhold many registrations for periods of trial. A society is thus allowed to be formed and to work for a time in order that it may be ascertained whether the members know their duties and understand co-operation. If, during this period of probation, the society proves satisfactory, registration is granted; if not, the society either receives further instruction or is disbanded without having to go through all the procedure of cancellation and liquidation. It is proposed to amend the local draft Ordinance to read as the Indian Act in this respect. The same amendment is proposed in the section dealing with the amendment of by-laws, as, unless the Registrar is given a certain amount of discretionary power in this respect, there is nothing to prevent a society from altering its by-laws in such a way that while it may comply with the provisions of the Ordinance, may yet be co-operative neither in spirit nor in intention.

Audit and inspection.

The statutory annual audit and the powers of inspection with access to all books, accounts, papers, etc., at all times conferred on the Registrar or persons

authorised on his behalf, are not only intended to afford an opportunity to check the books and methods of book-keeping and to enable the Registrar to satisfy himself that the society is carrying on its work in accordance with co-operative principles, but are designed to afford the Registrar an opportunity to assist and guide societies to better carry out their aims and objects.

De-officialisation.

It is desired to de-officialise the co-operative movement as much as possible, and in India very good progress has been made in this direction, and to this end several amendments are now proposed in the local draft Ordinance. In applying for registration a society now no longer needs to pass its application through the District Commissioner of the District, as his duties are so multifarious that he has not the time nor the special training to enable him to express an opinion on the merits of the proposal. Moreover, as the result of Ceylon experience, it has been decided that the president of a society which has borrowed money from Government need no longer be an officer of Government, but the Registrar has to certify on the loan application that he considers the President is a suitable person, nor need the District Commissioner now recommend the loan. In addition, it is proposed to delete from the draft Ordinance the right of various officers in the Political Service to inspect societies without the written authority of the Registrar, for the same reasons as already given in connection with the application for registration not now passing through the District Commissioner.

Department of Agriculture.

In the draft Ordinance the Director of Agriculture is nominated to be the Registrar of Co-operative Societies; this was objected to originally by the Legal Department and has since been queried by several critics. The reasons for this action were that the co-operative societies which it was desired to encourage were chiefly rural societies, and surely no Department should be better fitted than the Department of Agriculture to deal with such a problem. Moreover, naturally, cacao marketing would be one of the chief aims of these societies, and that subject is so tied up with questions of improvement of quality that the organisation of these societies becomes very technical and no other Department could undertake the task. It is proposed to amend this provision, however, to read that His Excellency the Governor shall nominate the Registrar of Co-operative Societies, but the Director of Agricul-

ture shall be Registrar until such times as the Governor makes another nomination.

Rulings as to eligibility.

The Eastern Province Provincial Council of Chiefs objected to the power given to the Registrar to decide on questions of age, residence or ownership of land in the case of an application for membership, alleging that the local native authority was surely in a better position to decide such questions. This objection arose through a misunderstanding of the intention of that section of the Ordinance. It was not intended that an individual applying for membership should have the right of appeal to the Registrar if he was dissatisfied with the decision of the Committee, but that, if the Committee disagreed, and could not come to a decision, they could appeal to the Registrar for a ruling, whose decision would be final. In order to avoid the question of ownership of land, which qualification for membership it has already been stated it is proposed to alter, and to make the meaning of this clause clearer, it is proposed to amend it on the following lines, that, when any question arises as to the qualification for membership of any person, the same shall be decided by the Committee. In event of disagreement, the Committee shall have the right of appeal to the Registrar, whose decision shall be final.

Liquidation.

The same body objected to the exclusion of the Native tribunals from jurisdiction in connection with the liquidation of societies whose registration had been cancelled. This is one of the chief privileges accorded to co-operative societies by the Ordinance, viz., the benefit of summary liquidation, whereby a liquidator is given wide powers to enable these proceedings to be expeditiously and cheaply carried out. To alter these provisions would be a serious mistake and the Government has no intention of proposing any amendments.

Restrictions on lendings.

The Provincial Council of Chiefs of the Eastern Province also queried the powers given to the Registrar in connection with the restriction of loans on movable property and objected to the prohibition of societies lending on mortgage of immovable property. The Gold Coast draft Ordinance purposely provides for the establishment of primary societies only, and such societies do not usually number amongst their members persons who are capable of transacting such difficult and complicated legal business as lending on mortgage, and the whole system of co-operative lending should be based on personal security and surety.

External transactions.

The power given to the Governor in Council to prohibit or restrict the transactions of a registered society with persons other than members was objected to by the same body, but some such provision is necessary in dealing with a more or less simple and primitive people as the local African. This power would only be used in extreme cases where it was found that unscrupulous persons were endeavouring to exploit these societies to the detriment of the latter.

Membership and voting.

The remaining points which it is proposed to amend are technical points generally affecting co-operative principles, and the Gold Coast is indebted to the Horace Plunkett Foundation for bringing these into prominence. The first of these is that the principle of one member—one vote be adhered to whether the societies be of limited or unlimited liability. This is a sound recommendation and one that should be insisted upon in all co-operative organisations. Then in the matter of restriction of membership of society the draft Ordinance laid down that no person shall be a member of more than one registered society without the approval of the Registrar. This is undoubtedly sound for societies of unlimited liability, where a person pledges himself to the full extent of his property for the debts of the society, but there can be no objection to a person being a member of more than one society of limited liability, as in each case his liability is restricted to the face value of the share or shares subscribed by him. It is proposed that this section now read that no person shall be a member of more than one society of unlimited liability. Another point is that, whilst the shares of a society of unlimited liability cannot be transferred to other than a member of the society, the shares of a limited liability society can be. It is proposed to amend this to read that no shares in any registered society may be transferred to other than a member of that society.

Amendments to rules.

The other points were, firstly, the omission from the Rules made under the Ordinance of a Clause authorising the calling of an Annual General Meeting of a registered society, and, secondly, the absence of provision regarding the basis on which a dividend or payment on account of profits would be made. It is proposed to insert that this dividend shall be paid on share capital ; thirdly, the amount which a society may borrow by raising loans or receiving deposits is restricted to three times the total paid-up share capital

and reserve fund, and it is proposed to delete these provisions from the Rules made under the Ordinance whereby the sum that a society may borrow from Government is limited to £200. This, together with the deletion of the necessity for the District Commissioner's recommendation and the appointment of an officer of the Government to act as President previously mentioned, means that the practice found by experience in Ceylon to be successful has been adopted.

Rate of dividend.

In the draft Ordinance, authority is given to prescribe the maximum rate of dividend that may be paid by societies with unlimited liability, and it is proposed to alter this so that this provision will apply to all societies, whether limited or unlimited, by the deletion of the words "of unlimited liability."

Cacao producers' societies.

Reference has already been made to the experimental co-operative societies for produce marketing that have been started by the Department during 1929. These societies embody some features not commonly met with elsewhere, and some explanation of these and the reasons for them might be of interest. Primarily, it must be remembered that these societies are experimental and that no hard and fast rules have been laid down, as it is desired to keep their organisation fluid until sufficient experience has been gained to enable this to be done.

Quality and price.

The controlling factor, that has limited the success of every attempt to improve and standardise the quality of the peasant cacao growers' produce has been the lack of machinery to enable the producer to realise a higher price for better quality. This state of affairs has been brought about by the peculiar system of marketing organisation that has been built up in this colony. Whilst admitting that a great deal of the credit for the extraordinary development of the Gold Coast as the world's largest cacao producer is due to the mercantile community, yet the system that has been evolved is not a satisfactory one from the point of view of either the merchants or the farmers. The basic trouble is that the merchants are too anxious to obtain the farmers' produce, and competition is so keen between the representatives of different speculative buying firms that the farmer is able to sell any quality of cacao he may produce.

Local marketing conditions.

The Gold Coast farmer, like all Africans, has a rational and logical dislike of expending any more

energy than the absolute minimum necessary to supply his wants. The cacao buyer, in order to attain his object, which is now to buy as large a tonnage as possible, quality having become a secondary consideration, has found it necessary to provide a most complex buying organisation. This organisation, which extends to practically every village in the cacao areas, encourages the natural indolence of the farmer, as all he has to do is to pluck, ferment and dry his cacao, and, on bringing it into the village, can realise cash for it immediately. The merchants thus assume the responsibility for the whole cacao crop, valued at eight to nine million pounds sterling, from the drying rack onwards. This is undoubtedly wrong, as these firms are risking all that money and naturally must have some return to insure them against loss. A system of advancing money against the crop even before it is harvested is becoming more common, and this lack of need for the farmer to undertake any responsibility in the marketing of his produce is having a most undesirable effect on the industry.

Differential prices.

When any propaganda in connection with the improvement of quality is undertaken amongst the local farmers, the question that the propagandist has always to answer is, " If we take more trouble in preparing our produce, will we get a better price ? " This has proved a stumbling-block for years, and one of the aims of these cacao marketing societies is to overcome this difficulty if possible. The idea is to link together a number of farmers in a village who will bulk and sell collectively their more carefully prepared cacao, the hope being that, if they are able to offer quantity as well as quality, they will be able to command recognition from the large exporters and receive a premium for better quality produce. It is recognised, of course, that a premium can only be offered for comparatively small quantities, but, if the movement spreads, the obvious result will be that better quality produce will be bought at a standard price and poorer quality at a correspondingly lower figure.

Model adopted.

The type of society that is being fostered for cacao marketing is based on the Eastern type of rural co-operative credit society of unlimited liability in many ways, and particularly in so far as the area of operations has been restricted to one village, so that members shall be well known to one another and able to exercise mutual supervision. Membership is restricted to *bona-fide* growers of cacao, who total 681 for

the 25 societies founded, the actual number of members varying from 11 to 59 in individual societies.

Special points.

Special provision is made in the by-laws for the preparation of higher grade cacao as well as restrictions binding members to sell all their produce through the society. These by-laws provide that members shall only prepare their cacao from sound, well-developed beans; that no member shall sell his cacao except through the society without the sanction of the Committee; and that no cacao other than that grown on the farms of members shall be handled by the society.

Subscription of capital.

The methods that have been adopted were to get the members to subscribe as much share capital as possible. These amounts have been devoted, in most cases, to the erection of a suitable cacao store and the purchase of such essentials as bags, twine, etc. Some societies, which have not been able to raise sufficient capital to build a store, have rented a suitable building. The possession of a store by a society is essential to enable the members' produce to be examined and bulked ready for certification by the Department of Agriculture before it is offered for sale.

Certification of produce.

On a member bringing his cacao to the society's store, it is examined by the Committee as to dryness and quality, and unsatisfactory lots are rejected. These may be dried further and picked over to remove obvious defects, or, if that rectification will not bring the produce to the required standard, the member may be granted permission to sell that lot to an outside buyer, which, incidentally, he never has any difficulty in doing. If the produce be accepted, it is weighed, the amount entered in the Cacao Register and in the member's pass-book, and put up in local standard bags of 140 lbs., which are stacked on battens clear of the floor. When a sufficient quantity has been collected, and it is desired to effect a sale, the local Inspector of Produce of the Department samples the consignment in accordance with the methods devised for use at the ports (*see* 1927 Year-Book). Each bag is sealed with a lead seal and a certificate of quality is given to the society which it can use in negotiating the sale of this cacao by open tender. It has been definitely laid down that all produce must be sold by open tender and that forward contracts are definitely forbidden.

A local difficulty.

On the cacao being delivered and paid for by the buyer, the cash received is distributed to members

according to the amount of cacao brought in. The society retains only 6d. per load of 60 lbs. to cover expenses, etc. The deduction of any amount, however small, was opposed by members, as they did not fully understand why what they termed "their profit" should be retained by the society. The position in this respect is most peculiar, since these members had no objection to subscribing share capital to start the society or for any purpose that came along, but they insisted that they got the full price paid to them that was realised for their cacao. After payments were made they willingly subscribed more share capital, but still insisted that they had a grievance, in that 6d. per load had been retained by the society. This is simply a misunderstanding, as after the season's work is over and a small dividend can be paid to them, it is hoped that this point will be cleared up successfully and no more trouble is anticipated.

Use of capital.

Only one society has had sufficient funds to grant to its members advances against their produce deposited in the society's store, but this should become an important part of the functions of these societies when they have become established. Up to the present the policy has been to get these societies to provide their own funds in order to make them realise, as far as possible, how much they can do to help themselves. The more a co-operative society can be made to do for itself the sounder will be its work, and the more effective and lasting are likely to be the results achieved. The aim is not to establish societies as a means of subsidising the farmer, but as a means of teaching him to conduct his business on sound lines by means of self-help and mutual help. This effort has been successful, as more than half of the societies started have, in one season, built a cacao store costing over £30, and all have subscribed a fair amount of share capital and provided themselves with the necessary bags, etc.

Liability.

These societies have been started on the basis of unlimited liability, and, from the experience of one season, it appears that limited liability will prove a sufficient obligation for the members to undertake. These societies have tangible assets (cacao stores, bags, etc.), their dealings with persons other than members are at present restricted to the sale of their produce (a credit and not a debit transaction), and they only make advances to their own members against cacao deposited in the society's store, so it is evident that limited liability is all that will be necessary.

Conclusion.

The full results of the first season's work are not yet available, and it is not possible to draw definite conclusions, but it would appear that a sound type of cacao marketing society has every chance of being successful, and it would most probably go a long way towards rectifying some of the defects of the present system of marketing cacao on the Gold Coast. Information up to date is given in the paper by Captain J. M. Wingate entitled "Improvement of Quality in Local Cacao by Co-operative Marketing, 1929–30," appearing elsewhere in this Year-Book.

PAPER No. III.

WORK OF CO-OPERATIVE SOCIETIES DURING 1929–30.

By J. M. DUNBAR.

The following notes indicate the progress made by co-operative societies formed since the introduction of the movement to this country.

In all thirty-one societies have been formed and are now awaiting registration under the proposed Ordinance. Of these, twenty-seven are Cacao Producers' Marketing Societies, one Rice Growers' Society, one Food Crops' Society and two Thrift and Loan Societies. The appended table (Appendix A) gives a list of the societies formed and shows details of their operations for the year ended April 30th, 1930.

It will be observed that some years previous to the introduction of the co-operative movement to this country three of the above-mentioned bodies had formed themselves into associations for the sale of their produce in bulk.

Obodan.—Started in 1915, this society was previously known as the Aburi-Nsawam Cocoa Growers Association. In its early stages it was fostered by the Department of Agriculture, and this assistance has been continued from time to time by officers of the Department.

Atasomanso.—Previously known as the Atasomanso Farmers Association, in which were incorporated the co-operative societies now known as Pechi and Kokobin, this society commenced to operate in 1918. It has always received the support, advice and encouragement of the Department of Agriculture. Last year this society obtained a premium of from 2s. to 2s. 6d. per load above ordinary market prices for its cacao.

Abokobi.—This society was first started in 1922 under the name of Abokobi Farmers Association. The members own a farm on which they grow food crops for sale in Accra. They also have a coffee plot of over 1 acre in extent and about 90 head of poultry, including chickens. In 1927, in order to facilitate the marketing of their produce, a motor lorry was purchased at a cost of £288. In addition to transporting the

society's produce the lorry was used for local passenger traffic. In July, 1928, a second lorry, costing £437, was purchased under the instalment system, and an amount of £39 still remains to be paid off. In 1928–29 the lorry earnings formed the major part of the revenue of this society. In view of the fact that the aims of the society are not of a purely co-operative nature, it is unlikely that it will be registered under the Co-operative Ordinance.

Membership.—The membership varies from ten in the case of Cheredom, in the Bisa area, a recently formed society, to seventy-two in the Agricultural and Forestry Training Centre, Kumasi.

Capital.—With one exception the authorised capital of all the societies formed is £500. Paid-up capital varies from £3 5s. for Dawa-Sutchoom in the Bisa area to £128 17s. for the Department of Agriculture (Head Office) Society. Not unexpectedly, some difficulty has been experienced in building up capital during the first year's working. This is especially noticeable in the Bisa area, where the capital of the societies formed is generally considerably lower than that of societies in other areas. There is no doubt that the general lack of money among small farmers is genuine, and that many of them are actually in debt.

Revenue from Sale of Cacao.—The revenue from sale of cacao was greatest in the Kumasi area. This may be accounted for by the fact that members in that area bring in all their cacao for sale through the societies. The co-operative movement has been longer established and is better known in that district. In certain other areas members brought in only a proportion of their crop, but there is every reason to believe that members will bring in practically all their cacao next season.

Expenditure.—Expenditure in the case of the Cacao Producers' Marketing Societies was chiefly for the erection or rent of a cacao store, purchase of cacao bags, stationery, etc. In the Abokobi Society it consisted principally of running costs of lorry, farm labour and caretaker's wages, stationery, etc. In the Head Office and Training Centre Societies the money was spent mainly in the purchase of canteen stores for retail.

Profits.—The profits of the Cacao Producers' Societies are made up chiefly of the deduction made by the society of 6d. per load of cacao sold through the society. Considerable opposition was experienced in obtaining the approval of members to this deduction, and in certain societies the opposition was so strong that it was considered advisable to waive this general ruling for the first year. Societies now appreciate the necessity for it, however, and have agreed that the deduction be made from next year's sales. Other sources which contribute in a small way to the profits are Bank interest, interest on loans, entrance fees, etc. Considerable

profits have been made by Head Office Society by the sale of canteen stores to members : for the year this amounted to £13 14s. 9d.

Loss.—The losses shown for the societies in the Oda area are due to depreciation on cacao stores and bags and to payments for stationery. No deduction of 6d. per load of cacao was made by societies in this area. In Abanase society the loss is due to depreciation on cacao bags and to rent of store ; this is another society in which no deduction for cacao sold was made. The loss of £70 8s. 9d. in the Abokobi Society is due to the deficit on the lorry account ; the repairs bill for the lorry was extremely high.

Dividends.—Dividends have been calculated at the rate of 7½% on the subscribed capital. Surplus profits, after deductions for reserve and payments for dividends, have been carried forward to next year.

Average Size of Lots of Cacao Brought In.—The attached table (Appendix B) is of interest as showing the average size of lots of cacao brought in by members in each area.

APPENDIX A.

Name of Society.	Date formed.	Membership.	Paid-up Capital. £ s. d.	Revenue from Sale of Cacao. £ s. d.	Expenditure. £ s. d.	Profit during Year. £ s. d.	Loss during Year. £ s. d.	Amount placed to Reserve Fund. £ s. d.	Dividend paid. £ s. d.	Quantity of Cacao sold. T. C. Q. Lbs.	Cacao Store built or rented.
CACAO PRODUCERS' MARKETING SOCIETIES. BISA AREA (EASTERN PROVINCE).											
Dawa-Sutchoom	6th Aug., 1929	13	3 5 0	278 13 4	29 6 6	7 3 0	—	—	—	9 6 2 12	Built
Kabo ..	1st Aug., 1929	15	3 15 0	160 5 0	5 0 0	0 19 6	—	—	—	5 14 1 24	Rented
Huhunya ..	6th Aug., 1929	21	7 19 0	182 16 3	—	5 8 6	—	1 9 7	—	5 7 1 8	Rented
Odometa ..	30th May, 1929	45	11 5 0	384 17 6	12 8 6	1 17 0	—	—	—	13 12 0 0	Rented
Obawale ..	23rd Aug., 1929	30	35 19 0	290 15 5	22 4 0	—	—	—	—	17 11 1 0	Built
Prekumase ..	20th July, 1929	15	3 15 0	173 9 4	5 0 3	0 15 0	—	—	—	5 13 0 4	Rented
Sutrisu ..	27th May, 1929	27	6 15 0	314 12 1	—	1 7 0	—	—	—	11 16 2 22	Rented
Cheredom ..	10th Feb., 1930	10	4 5 0	149 1 4	5 5 6	0 10 0	—	—	—	5 13 3 0	Rented
Akotue ..	25th July, 1929	18	4 10 0	—	—	—	—	—	—	—	—
	Total ..	194	81 8 0	1,934 10 3	79 4 9	18 0 0	—	1 9 7	—	74 15 0 14	
ODA AREA (CENTRAL PROVINCE)											
Oda	5th June, 1929	19	74 16 0	339 2 5	4 18 4	—	10 2 6	—	—	9 16 1 17	Built
Akim Swedru	18th June, 1929	27	73 7 0	643 3 8	81 5 11	—	9 0 8	—	—	18 12 2 0	Built
Ewusa ..	27th Aug., 1929	16	80 5 0	548 9 10	84 15 7	—	13 0 7	—	—	13 5 2 4	Built
Nkwanta ..	18th Aug., 1929	14	14 15 0	80 9 0	14 16 5	—	6 17 6	—	—	2 7 0 26	Rented
Nkwantin ..	12th Aug., 1929	11	24 3 0	177 6 0	16 19 4	—	3 8 9	—	—	5 5 2 4	Rented
Ntronang ..	12th May, 1929	28	31 6 0	442 4 6	27 13 1	—	10 17 0	—	—	13 10 2 24	Rented
	Total ..	115	298 12 0	2,230 15 5	230 8 8	—	53 7 0	—	—	62 17 3 19	
KUMASI AREA (ASHANTI).											
Atasomanso	1918	46	56 10 0	822 19 5	9 15 0	12 5 10	—	3 1 6	4 4 9	26 7 3 2	Built
Pechi ..	1918	59	74 0 0	1,097 12 0	50 1 0	15 19 1	—	4 13 8	5 11 0	35 10 0 26	Built
Kokobin ..	1918	40	47 0 0	535 5 9	40 6 4	4 8 7	—	1 12 1	3 10 6	17 5 0 10	Built
Agona ..	1st May, 1929	33	51 11 0	842 9 7	37 6 11	8 7 1	—	2 1 9	4 4 9	27 3 3 0	Built
Ankasi ..	20th May, 1929	36	79 10 0	987 5 0	38 19 8	14 3 1	—	3 10 9	5 19 3	31 15 0 0	Built
Jamasi ..	1st April, 1929	38	34 0 0	414 19 3	36 18 6	8 13 9	—	2 3 5	2 11 0	13 14 1 4	Built
Asamang ..	1st May, 1929	29	45 5 0	357 11 0	30 15 11	4 7 8	—	1 2 0	3 5 8	11 15 3 0	Built
Bipoa ..	1st July, 1929	38	28 0 0	716 9 2	30 8 1	23 1 1	—	5 15 3	2 2 0	23 17 2 0	Built
Ntonso ..	13th May, 1929	16	14 10 0	—	1 4 6	—	0 4 5	—	—	—	
	Total ..	335	430 6 0	5,774 11 2	275 15 11	91 6 2	0 4 5	24 0 5	31 8 11	187 9 1 14	

APPENDIX A.—(*Continued.*)

Name of Society.	Date formed.	Membership.	Paid-up Capital. £ s. d.	Revenue from Sale of Cacao. £ s. d.	Expenditure. £ s. d.	Profit during Year. £ s. d.	Loss during Year. £ s. d.	Amount placed to Reserve Fund. £ s. d.	Dividend paid. £ s. d.	Quantity of Cacao sold. T. C. Q. Lbs.	Cacao Store built or rented.
NSAWAM AREA (EASTERN PROVINCE).											
Obodan ..	1915	44	38 14 0	169 9 9	9 1 6	5 11 1	—	1 8 0	2 18 0	5 15 1 4	Rented
Otoasi ..	1st Oct., 1929	14	7 14 0	237 11 0	3 11 6	5 5 6	—	1 6 5	0 14 0	7 7 3 12	Rented
	Total ..	58	46 8 0	407 0 9	12 13 0	10 16 7	—	2 14 5	3 12 0	13 3 0 16	
PECHI AREA (EASTERN PROVINCE).											
Abanase ..	27th May, 1929	22	51 11 0	384 1 1	18 4 2	—	9 10 7	—	—	16 5 0 0	Rented
RICE SOCIETY.											
Esiama (Appolonia)	Nov., 1928	34	97 15 0	*7 10 9	8 5 1	0 3 1	—	—	—	—	—
FOOD CROP SOCIETY.											
Abokobi (East. Province)	1922	62	91 5 0	†281 2 3	354 3 0	—	70 8 9	—	—	—	—
THRIFT AND LOAN SOCIETIES.											
Dept. of Agric. Head Office	Feb., 1928	54	128 17 0	‡242 16 8	316 9 9	17 13 5	—	9 13 2	9 13 6	—	—
Agric. and Forestry Tr. Centre (Kumasi)	July, 1928	72	102 14 0	‡10 2 10	15 12 3	5 6 2	—	—	—	—	—
	Total ..	126	231 11 0	252 19 6	332 2 0	22 19 7	—	9 13 2	9 13 6	—	
	Grand total ..	946	1,328 16 0	11,272 11 2	1,310 16 7	143 5 5	133 10 9	37 17 7	44 14 5	354 10 2 7	

* Sale of rice.
† Sale of farm products and lorry earnings.
‡ Sale of canteen stores.

APPENDIX B.

Average Size of Lots of Cacao Brought in by Members.

Bisa Area.		Oda Area.		Kumasi Area.		Nsawam Area.		Pechi Area.	
Quantity.	Number of Members.	Quantity.	Number of Members.	Quantity.	Number of Members.	Quantity.	Number of Members.	Quantity.	Number of Members.
No cacao.	21	No cacao.	29	No cacao.	32	No cacao.	29	No cacao.	3
1– 5 loads	20	1– 5 loads	1	1– 5 loads	24	1– 5 loads	4	1– 5 loads	2
5– 10 ,,	40	5– 10 ,,	19	5– 10 ,,	63	5– 10 ,,	7	5–10 ,,	1
10– 15 ,,	40	10– 15 ,,	15	10– 15 ,,	43	10–15 ,,	5	10–15 ,,	3
15– 20 ,,	17	15– 20 ,,	8	15– 20 ,,	47	15–20 ,,	2	15–20 ,,	5
20– 25 ,,	10	20– 25 ,,	6	20– 25 ,,	25	20–25 ,,	6	20–25 ,,	1
25– 30 ,,	6	25– 30 ,,	4	25– 30 ,,	11	25–30 ,,	1	25–30 ,,	2
30– 35 ,,	3	30– 35 ,,	10	30– 35 ,,	15	30–35 ,,	1	30–35 ,,	–
35– 40 ,,	9	35– 40 ,,	6	35– 40 ,,	18	35–40 ,,	1	35–40 ,,	–
40– 45 ,,	2	40– 45 ,,	8	40– 45 ,,	10	40–45 ,,	1	40–45 ,,	2
45– 50 ,,	3	45– 50 ,,	2	45– 50 ,,	4	45–50 ,,	–	45–50 ,,	1
50– 55 ,,	1	50– 55 ,,	2	50– 55 ,,	5	50–55 ,,	1	50–55 ,,	1
55– 60 ,,	–	55– 60 ,,	2	55– 60 ,,	6	55–60 ,,	–	55–60 ,,	–
60–130 ,,	4	60–205 ,,	4	60–125 ,,	17	60–65 ,,	–	60–70 ,,	1
Average quantity per member bringing in cacao.	17 loads	Average quantity per member bringing in cacao.	27 loads	Average quantity per member bringing in cacao.	46 loads	Average quantity per member bringing in cacao.	17 loads	Average quantity per member bringing in cacao.	24 loads
Average quantity per member, including those who did not bring in cacao.	15 loads	Average quantity per member, including those who did not bring in cacao.	20 loads	Average quantity per member, including those who did not bring in cacao.	41 loads	Average quantity per member, including those who did not bring in cacao.	8 loads	Average quantity per member, including those who did not bring in cacao.	21 loads

PAPER No. IV.

IMPROVEMENT OF QUALITY IN LOCAL CACAO BY CO-OPERATIVE MARKETING 1929–30.

By J. McN. WINGATE.

The question of improvement of quality in cacao has for some years been a matter of considerable importance to the Gold Coast. The necessity for raising the standard of quality of this, our main export, is greater to-day than it has been in the past, due mainly to the fact that other West African colonies, both British and French, are gradually increasing their cacao production.

Improvement in quality is obviously more difficult to effect in a country such as the Gold Coast, where the industry is established on a large scale, than in the other West African colonies, where the output is still comparatively low. It therefore follows that unless serious efforts are directed at improvement in the Gold Coast the average quality of this country's cacao will be, in a few years' time, considerably below that of the competing colonies.

A system of produce inspection at ports was started in 1927 on voluntary lines. After just over three years' working this scheme has provided the colony with very valuable figures regarding the quality of cacao exported, but has effected little or no improvement in that quality. As there is no legislation in this country prohibiting the export of low-grade cacao, it is very unlikely that produce inspection at ports alone will aid in our efforts at improvement.

CO-OPERATIVE EFFORTS.

Realising this, the Department of Agriculture has commenced an Up-country Scheme of Inspection and Certification, having as its sole object the improvement of cacao. This scheme is at present closely associated with the development of Cacao Marketing Co-operative Societies that have been formed in two areas in the Colony and one area in Ashanti. In the colony there are eight societies in the Bisa district of the Eastern Province, in the charge of Mr. F. Pyatt, with a total membership of 182; whilst Mr. E. D. Hill, in the

ATASAMANSO CO-OPERATIVE SOCIETY CACAO STORE.

Western Akim district of the Central Province, has six societies, with a total membership of 114. In Ashanti there are eight societies, five of which are in charge of Mr. D. V. Parkes and three under the supervision of Mr. T. Hunter. The total membership of the eight societies is 318.

Only *bona-fide* cacao farmers residing within each area are eligible for membership of these societies. In most cases societies have built a suitable store, using funds subscribed by the members. Where funds have not been sufficient a building has been rented to serve as a store until the money necessary is available. This means that produce can now be stored for considerable periods without much fear of deterioration from mould growth or weevil attack. Before these stores were erected many farmers stored their cacao under most unsatisfactory conditions, and were consequently forced to make quick sales, otherwise the percentage defects in their produce rapidly increased. The better storage conditions in themselves are a definite step towards the desired improvement in quality.

SYSTEM OF EXAMINATION AND CERTIFICATION.

The constitution of these societies has been fully dealt with in Mr. A. W. Paterson's Paper No. II of this publication. Each society has elected its president and committee, and the following rules and regulations have been drawn up: Before entry to a society's store all cacao is turned out on to a clean surface and examined for dryness. Cacao which is not thoroughly dry is rejected. In testing for quality a sufficient number of beans are cut up to ensure that only lots showing 90% purity and over are admitted. After admittance the cacao is bagged and stacked.

The Department of Agriculture has posted a European Inspector of Plants and Produce to each area to foster the movement and to examine and certify each society's cacao. When the quantity of cacao in store is thought large enough to attract European buyers samples are taken from the bags, cut up and examined, in the same way as at the ports. A certificate of quality is then issued to the society and is presented to the prospective buyer when negotiations for a sale are taking place. This examination and certification is always done by the European officer. After testing for quality the bags are sewn up and sealed with a lead seal. The press used for sealing has on one die the Colony's mark and on the other a number. This number is personal to the Inspector of Produce in order that the inspector of a particular parcel can always be traced. When an officer is relieved, the relieving officer is issued with his own die and does not take over that of the other officer.

OUTPUT OF SOCIETIES.

The following amounts of cacao have been received into each society:—

Eastern Province.

Bisa Area.	Membership.	Amount of Cacao brought in.			
		Tons.	Cwts.	Qrs.	Lbs.
Huhunia	21	5	5	0	0
Sitrisu	27	11	16	1	0
Odometa	43	11	15	0	0
Obawale	30	17	11	1	0
Kabo	15	5	4	0	19
Dawa-Sutchoom	13	8	12	2	0
Prekumase	15	5	6	0	5
Akutue	18	—	—	—	—
Total	182	65	10	0	24

Central Province.

Western Akim Area.					
Oda	19	9	15	0	0
Akim Swedru	26	18	11	1	0
Ewusa	16	13	5	0	0
Nkwanta	14	2	6	1	0
Nkwatin	11	5	6	1	0
Ntronang	28	13	10	0	0
Total	114	62	13	3	0

Ashanti.

Kumasi Area.					
Atasimanso	46	20	18	3	10
Pechi	59	28	2	3	16
Kokobin	40	15	6	1	20
Ankasi	37	37	14	3	8
Agona	33	27	2	2	0
Jamasi	36	13	5	0	10
Asamang	29	11	1	2	11
Bipoa	38	21	18	3	0
Total	318	175	10	3	19

QUALITY OF SOCIETIES' PRODUCE.

The result of the examination of cacao in societies' stores will be seen in the following tables :—

Society.	Average Percentage of Defects.								
	American Standard.		For Departmental Records.				Liverpool Standard.		
	Weevilly, but not Mouldy.	Mouldy.	Germinated.	Slaty.	Weevilly.	Defective.	Slaty.	All other Defects.	Good.
EASTERN PROVINCE.									
Bisa Area.									
Huhunia	0.10	0.55	0.95	0.85	0.10	3.50	0.85	5.10	94.05
Sitrisu	0.35	1.05	0.35	0.65	0.40	0.85	0.65	2.65	96.70
Odometa	0.05	0.10	0.30	0.25	0.05	0.50	0.25	0.95	98.80
Obawale	0.00	0.55	0.00	0.55	0.10	0.55	0.55	1.20	98.25
Kabo	0.00	0.40	1.30	2.45	0.10	1.05	2.45	2.85	94.70
Dawa-Sutchoom ...	0.40	0.50	1.00	0.25	0.40	1.15	0.25	3.05	96.70
Prekumase ...	0.15	0.25	0.10	0.05	0.15	0.90	0.05	1.40	98.55
Akutue	—	—	—	—	—	—	—	—	—
CENTRAL PROVINCE.									
Western Akim Area.									
Oda	0.00	0.04	2.20	0.50	0.00	1.50	0.50	3.90	95.60
Akim Swedru ...	0.00	0.30	0.90	0.30	0.00	2.30	0.30	3.40	96.30
Ewusa	0.00	0.40	0.50	0.30	0.00	0.50	0.30	1.20	98.50
Nkwanta	0.00	0.00	0.80	0.40	0.00	0.80	0.40	1.80	97.80
Nkwatin	0.00	0.00	0.50	1.00	0.00	0.80	1.00	1.30	97.70
Ntronang	0.00	0.40	0.50	2.60	0.00	0.50	2.60	1.50	95.90
ASHANTI.									
Kumasi Area.									
Atasimanso ...	0.00	0.50	0.20	0.10	0.08	0.50	0.10	1.20	98.70
Pechi	0.00	0.80	0.03	0.43	0.00	0.06	0.40	0.90	98.70
Kokobin	0.00	1.00	0.30	0.30	0.00	0.20	0.30	1.50	98.20
Ankasi	0.00	0.82	0.05	0.20	0.00	0.22	0.20	1.10	98.70
Agona	0.00	0.50	0.63	0.96	0.01	0.46	0.96	1.44	97.60
Jamasi	0.00	0.90	1.70	1.20	0.05	0.45	1.20	2.40	96.40
Asamang	0.02	0.86	2.30	4.30	0.03	0.30	4.30	2.90	92.80
Bipoa	0.00	0.50	0.95	1.20	0.05	0.10	1.20	1.35	97.45

It will be seen from the above figures, which are the averages of samples taken from all lots in each society's stores, that the quality of these co-operative societies' cacao is distinctly high.

The main defects are germinated beans and slatiness, both of which can be controlled by harvesting at the proper time and by efficient fermentation.

As Government is not authorised to publish the figures obtained at the ports relating to the analysis of defects in merchants' cacao, it is not possible to compare the quality of societies' cacao with the average for the Colony. However, there is no doubt that the quality of cacao as produced by co-operative societies is far higher than that average. This superior quality is the result of better preparation and of the improved storage conditions up-country.

DIFFERENTIAL PRICES.

The fact that merchants in the Colony and in Ashanti have paid, or have offered, premia on quality for societies' cacao has stimulated to a certain extent the desire for improvement amongst farmers. The highest premium paid was 1s. 9d. per load of 60 lbs., and the lowest 9d. per load with an average of 1s. 6d. per load.

In some districts, however, the farmer is not satisfied that the premium is sufficient to compensate him for the extra labour and trouble expended in effecting the improvement. It has been advanced by some farmers that other producers who have made no effort to raise the quality of their cacao have received from African sub-brokers the same price as that received by members of the societies from the European merchants. This can only mean that these small brokers are adopting some of the following underhand methods in buying :—

(*a*) Using scales or spring balances which are inaccurate in the brokers' favour.

(*b*) Making an unfair deduction for wet cacao.

(*c*) Filling up declared stocks on a falling market.

Assuming that the above practices are in operation, they will certainly work against any scheme for improvement in quality. It is also extremely difficult to convince the small farmer that he will get a fairer deal from the merchants than he is getting from the unscrupulous small buyer.

It would appear that a possible solution to these difficulties would be the distribution of appropriate pamphlets, in the vernacular, to farmers explaining the situation and warning them to satisfy themselves that the brokers are using accurate scales and that only fair deductions are made for wet cacao. To prevent the small brokers buying as in (*c*) above is a matter which only their employers can deal with. Until this is taken up by the merchants and dealt with successfully considerable improvement in the quality of our cacao cannot be expected.

It must be understood, however, that no substantial improvement can be effected unless the farmer is prepared to do his share. At present the Gold Coast farmer has a false idea of his economic

position, due mainly to the adverse effect of the post-war boom. He has got to realise that cacao prices will come down, and that to make cacao farming a continued financial success he will have to supervise his farm himself instead of employing caretakers, and in many cases will have to do the actual work if he desires satisfactory returns. The Gold Coast farmer will have to understand that yields cannot be maintained unless he undertakes some form of tillage on his farm.

GENERAL AGRICULTURAL IMPROVEMENT.

It is not intended that co-operative societies confine their activities solely to the marketing of the crop, but it is hoped that co-operation will be extended to the farms. In other words, that the members of each society will work co-operatively on farm sanitation and on harvesting.

At present a large number of farms are not supervised or worked by the owners, but are in the hands of caretakers. The expression "caretaker" is somewhat misleading, as the person who fills this *rôle* is often of a tribe from the Northern Territories where no cacao is grown, and whose knowledge of cacao cultivation is therefore extremely meagre.

The owners expect the caretaker to do everything on the farm, from sanitation to harvesting, for which he is paid one-third of the crop. It is obvious that under this system farms are not likely to receive much attention in the way of draining, pruning, and in cultivation in general, and that the only operation which will be considered is the actual harvesting. In order to prove to the farmer that the proper care of his farm would be worth his while to supervise personally an experiment is now being carried out on a farm at Ntronang (Western Akim District) on the following lines :—

The owner is personally supervising all work on this farm under the direction of an officer of the Department of Agriculture. It is hoped in this experiment to increase the yield by harvesting at the proper time, to reduce expenditure by proper supervision, and to improve the general health of the trees by efficient sanitation and, consequently, to effect an improvement in the quality of the cacao. If the above experiment is successful the intention is to extend this method of working to the Ntronang Co-operative Society's farms and to carry out all farming operations on co-operative lines. This would mean that the society would employ its own labour, and, by each member taking his turn at supervising the work or by paying another member to deputise for him, would act as its own caretaker, thereby raising the efficiency of the work.

It is not expected that such a scheme will be put in operation without opposition, but, provided that the necessary patience is exercised by Government and by the farmer, the difficulties which will be met with ought not to be unsurmountable.

PREMIUM AND PENALTY.

Assuming that this question of cacao improvement is of importance to the merchants of the Gold Coast, it is only reasonable to expect that they will assist Government in its efforts in this direction.

To achieve the best results merchants would assist considerably if they bought, firstly, on quality by having a fixed price for first-grade cacao (97% purity) and a price scale for inferior grades, and, secondly, if they stopped the practice of advancing large sums of money to their brokers and small buyers. This system of advances not only hampers progress on cacao improvement but works against the merchants themselves.

Manufacturers, on the other hand, would assist very considerably if they would state their quality grades so that producers would know what to strive for. Such a declaration of grades by manufacturers would greatly facilitate the marketing of cacao in the Gold Coast.

PAPER No. V.

INVESTIGATIONS INTO THE RELATIVE HUMIDITY OF AIR IN CACAO STORES.

By B. T. STEEMSON.

The response of dried cacao beans to changes in the relative humidity of the air surrounding them has already been demonstrated by this Department (*vide* Dade, Year-Book, 1928, Paper X, and Scott, Year-Book, 1928, Paper IX), but the investigations referred to were concerned with loose beans rather than with dried cacao in bags.

In October, 1929, the opportunity arose for investigational work of this nature to be carried out in one of the cacao storing-sheds at Takoradi Harbour, and the writer was deputed to carry out the investigation. A hygrometer tower was set up at approximately the centre point of the shed, containing three hygrometers, one at the floor level, one about 13 feet above the floor, and the third about 25 feet above the floor. Later two more hygrometers were stationed outside the shed, one on the landward side, the other on the seaward side. Ten bags of cacao from the Department's station at Kumasi were brought into the shed and were divided into three lots, one of four bags, two of three, each lot being placed in a different part of the shed, but no lot was nearer than 50 feet to any door. A Brown-Duval Moisture Tester was used in determining the moisture-content of cacao samples.

The general scheme of work was to take samples each week from the three lots of cacao, to examine them for any change in condition, including increase or decrease in moisture content, and to attempt to correlate the relative humidity of the air in the shed with the moisture contents of the cacao.

Attention was first directed to the storage-sheds in which these investigations were carried out by the occurrence of a fur of calcium acetate crystals on the exterior of some of the cacao-bags stored therein. Further trials are needed, aimed at ascertaining the conditions under which calcium acetate forms, but it was assumed that, in addition to acetic acid from cacao and lime from some external source, it was necessary that free moisture be present in the meshes of the bags. This free moisture would dissolve acetic acid and lime and form the acetate. The figures in this paper show that with the range of air-humidities occurring in the sheds, bags did not absorb enough moisture for calcium acetate to be formed.

(*Sgd.*) G. Auchinleck.

METHOD OF SAMPLING.

To sample any one lot the beans were turned out from the bags on to a tarpaulin and the heap was thoroughly mixed with a shovel. Ten samples were then taken at random from the heap and the beans were immediately rebagged. The samples were analysed, the average percentage of defects for the ten samples was determined, and it is those averages which appear in this paper.

The beans which were used for moisture-determination were selected at random from the ten samples taken from the heap, and the moisture tests were always done as soon as possible after each sampling.

Table I shows the figures for fourteen weekly analyses of the three lots of cacao from the Kumasi Experiment Station, and it will be immediately noticed that each lot varies only very slightly during the period covered by the investigation. The defect which is most likely to develop under inferior storage conditions is mouldiness. Assuming that the storage shed is water-tight, an increase in the percentage of mouldy beans may either be induced, because the relative humidity of the air in the shed is consistently high, when the hygroscopic qualities of cacao beans will cause them to absorb moisture up to a point when they are liable to mould, or it may be due to the cacao being insufficiently dried before being stored.

Inspection of the figures in Table I shows that no real increase in either mouldiness or any other defect took place during the thirteen weeks the bags were in the store, the small variations clearly being due to sampling chances.

TABLE I.

TABLES OF AVERAGES OF EACH BATCH OF SAMPLES.

Kumasi (Agric. Dept.) Lot No. 1. Entered Shed 17/10/29.

Date of Analysis.	No. of Samples.	Percentage of Defects.					Purity.	Moisture % Cacao
		Mouldy.	Germ.	Slaty.	Weevilly.	Defective.		
17/10/29	10	0.5	0.0	0.0	0.0	1.0	98.5	6.5
24/10/29	10	1.3	0.2	0.1	0.0	1.8	96.6	6.6
31/10/29	10	0.6	0.3	0.3	0.0	3.8	95.3	7.4
7/11/29	10	0.6	0.2	0.0	0.1	1.3	97.8	8.0
13/11/29	10	0.8	0.0	0.0	0.0	1.6	97.7	8.0
20/11/29	10	0.6	0.2	0.1	0.0	1.0	98.1	8.2
27/11/29	10	0.4	0.1	0.0	0.0	1.3	98.2	8.1
4/12/29	10	0.7	0.0	0.1	0.0	1.7	97.5	8.0
11/12/29	10	1.6	0.0	0.0	0.2	1.7	97.8	7.9
18/12/29	10	0.9	0.0	0.1	0.0	0.7	98.3	8.0
24/12/29	10	0.4	0.0	0.1	0.0	1.0	98.5	8.0
31/12/29	10	0.9	0.0	0.0	0.0	0.4	98.7	7.6
9/ 1/30	10	0.4	0.0	0.0	0.0	0.4	99.2	7.4
16/ 1/30	10	0.7	0.0	0.0	0.0	0.6	98.7	7.2

TABLE I—(*continued*).

Kumasi (*Agric. Dept.*) *Lot No.* 2. *Entered Shed* 17/10/29.

Date of Analysis.	No. of Samples.	Percentage of Defects.					Purity.	Moisture % Cacao.
		Mouldy.	Germ.	Slaty.	Weevilly.	Defective.		
17/10/29	10	0.8	0.1	0.0	0.0	0.8	98.3	6.5
24/10/29	10	1.4	0.1	0.0	0.0	0.5	98.1	6.5
31/10/29	10	1.0	0.0	0.0	0.0	3.9	95.1	7.1
7/11/29	10	0.5	0.0	0.0	0.0	1.2	98.3	7.3
14/11/29	10	1.5	0.1	0.2	0.0	0.3	97.9	7.4
21/11/29	10	0.9	0.3	0.0	0.0	0.5	98.3	7.7
28/11/29	10	1.3	0.1	0.0	0.0	0.8	97.8	7.8
5/12/29	10	1.4	0.0	0.0	0.0	0.5	98.1	7.8
11/12/29	10	0.9	0.0	0.2	0.0	0.3	98.6	7.4
18/12/29	10	0.7	0.0	0.0	0.0	0.8	98.5	7.8
27/12/29	10	1.4	0.0	0.2	0.0	0.4	98.0	8.0
1/ 1/30	10	0.7	0.0	0.1	0.0	0.4	98.8	7.6
9/ 1/30	10	1.0	0.3	0.0	0.0	0.2	98.5	7.7
16/ 1/30	10	1.5	0.0	0.1	0.0	0.4	98.0	7.4

Kumasi (*Agric. Dept.*) *Lot No.* 3. *Entered Shed* 17/10/29.

Date of Analysis.	No. of Samples.	Percentage of Defects.					Purity.	Moisture % Cacao.
		Mouldy.	Germ.	Slaty.	Weevilly.	Defective.		
17/10/29	10	1.2	1.1	0.0	0.0	0.6	97.4	6.5
24/10/29	10	1.2	0.1	0.1	0.0	1.8	96.8	6.7
31/10/29	10	1.2	0.3	0.1	0.0	1.5	97.1	7.1
7/11/29	10	1.1	0.2	0.1	0.0	0.5	98.2	7.8
14/11/29	10	0.5	0.3	0.0	0.0	1.0	98.2	8.1
21/11/29	10	0.6	0.2	0.3	0.1	2.0	96.9	8.3
28/11/29	10	0.4	0.1	0.0	0.0	1.4	98.1	8.2
5/12/29	10	0.8	0.0	0.0	0.3	0.6	98.3	7.9
13/12/29	10	0.4	0.0	0.0	0.1	1.3	98.2	7.8
19/12/29	10	0.4	0.0	0.1	0.4	0.8	98.5	8.1
27/12/29	10	0.4	0.0	0.0	0.0	1.2	98.4	8.1
2/ 1/30	10	1.1	0.1	0.0	0.2	0.1	98 6	7.8
9/ 1/30	10	0.6	0.1	0.0	0.3	0.5	98.5	7.8
16/ 1/30	10	2.1	0 0	0.0	0.2	0.8	97.1	7.7

RELATIVE HUMIDITY OF AIR IN RELATION TO MOISTURE CONTENT OF CACAO IN THE STORE.

Although the response to changes is not marked, there seems to be a tendency, shown in Table I, for the samples to establish a moisture content equilibrium between 7.4 and 8. If we take the average humidity at floor level over the period to be 77, the corre-

sponding figures in I. L. Scott's Moisture per Cent. (Year-Book, 1928, Paper IX) Relative Humidity curve gives the figure 7.3 as the equilibrium-point for moisture per cent. cacao, so there is a general agreement between three lots of cacao and the curve quoted. Lot No. 3 was designedly placed at a point in the shed where the soil underneath the floor boards was damper than elsewhere on account of a faulty drain, which may account for the difference between this lot and the other two. Several factors militated against obtaining a close response such as found by Scott. First, the changes in humidity were not greater nor of long duration ; secondly, the bags must necessarily mask the response of the beans in them to a certain extent, and probably nullify the effect of small changes in humidity ; thirdly, the spaces between the hygrometer tower and the three lots of cacao would sometimes be vacant, while at other times it would be filled by blocks of bags which were awaiting shipment.

There are, however, two facts which emerge from the results obtained : first, the average moisture content of the cacao remained below 8%, and no increase in moulding appeared (*vide* Table I) ; secondly, the average humidity of the air at floor level was below 82%, and, similarly, there was no increase in moulding. These two facts are of importance in view of previous work by R. H. Bunting and H. A. Dade (Year-Book, 1928), showing that cacao, which is dried to a moisture content of 8% or under and is stored in an atmosphere whose average daily humidity is less than 82%, is not liable to deterioration during storage.

In addition to the work on the cacao from the Kumasi Experiment Station, sampling on similar lines was carried out on a number of consignments of merchants' cacao which were brought into the shed, and in all cases they showed no deterioration during the time they were awaiting shipment (a period varying from one to six weeks), nor did the moisture content of any consignment advance beyond 8.1%.

RELATIVE HUMIDITY OF AIR IN THE SHED AT DIFFERENT LEVELS.

(*N.B.*—The Average Daily Humidities are calculated from readings at 4 a.m., 8 a.m., Noon, 4 p.m., 8 p.m., and Midnight. In Table III are given readings at these hours.)

Table II demonstrates the difference in relative humidity between the air inside and that outside. It may be reasonably concluded that the dryness of the air at floor level is due to a current of air along the lower level resulting from the doors of the shed being open all day ; moreover, since there are usually about twenty boys working in the shed, their warm and moist breath ascending towards he ventilators in the roof must contribute slightly towards establishing the difference observed.

TABLE II.

Average Daily Humidities—Comparisons between Four Hygrometers; Three Inside the Shed and One Outside.

Date.	No. 1 (25 feet above).	No. 2 (13 feet above).	No. 3 (Floor level).	No. 4 outside (Landward).
November 4	81.3	—	77.0	—
,, 5	80.3	—	76.1	—
,, 6	79.3	—	76.6	—
,, 7	77.8	—	76.6	—
,, 8	82.3	—	76.1	—
,, 9	79.5	—	75.5	—
,, 10	81.8	—	77.8	—
,, 14	79.5	—	77.0	—
,, 15	77.5	—	77.1	—
,, 19	80.0	80.0	77.8	80.3
,, 20	79.1	80.0	79.3	82.1
,, 21	81.3	80.5	77.0	82.1
,, 22	76.6	78.3	78.6	80.7
,, 23	79.8	79.0	79.8	82.3
,, 29	79.8	80.0	76.5	82.1
,, 30	81.0	80.1	78.0	84.1
Means for November ..	79.8	79.7	77.3	82.0
December 1	81.0	81.6	79.3	89.3
,, 2	80.6	84.0	77.3	85.8
,, 3	79.0	81.5	75.8	84.3
,, 4	80.6	81.5	75.6	86.3
,, 5	81.5	84.6	75.1	84.6
,, 6	82.3	85.3	77.0	86.1
,, 7	89.1	89.6	82.3	97.1
,, 10	80.3	79.6	76.4	85.0
,, 11	80.0	77.5	74.3	84.6
,, 12	77.1	77.0	75.0	80.5
,, 13	79.8	80.6	76.1	82.0
,, 17	76.5	81.1	74.6	80.1
,, 18	76.6	79.5	75.8	81.9
,, 19	78.8	81.8	74.8	83.6
,, 20	79.6	79.5	75.1	84.8
,, 21	81.1	80.1	74.0	88.6
,, 22	78.1	80.5	79.0	87.1
,, 23	78.8	78.8	76.5	83.3
,, 24	81.0	81.8	78.3	85.8
,, 25	80.5	81.3	76.8	86.8
,, 28	79.3	80.6	75.8	82.6
,, 29	82.0	79.3	76.1	85.3
,, 30	79.8	78.6	76.0	83.6
,, 31	79.3	77.8	76.8	84.3
Means for December ..	80.1	81.0	76.4	84.7
January 1	81.5	79.8	78.0	87.5
,, 3	81.1	81.1	80.3	88.1
,, 4	80.6	84.1	81.0	88.3
,, 5	81.0	83.0	81.8	91.0
,, 6	81.1	83.3	78.8	90.3
,, 7	80.5	83.0	78.3	88.3
,, 8	79.6	81.3	78.3	87.6
,, 9	80.1	82.1	78.3	87.3
,, 10	82.6	81.1	78.5	85.7
,, 11	82.7	82.3	77.8	86.8
,, 12	83.0	81.6	78.8	87.5
,, 13	83.5	83.5	81.1	93.8
,, 14	80.0	82.3	80.8	89.8
Means for January ..	81.3	82.2	79.3	87.7

On November 16th two more hygrometers were brought into use. One was placed in the tower, approximately 13 feet above the floor level, the other outside the shed on the landward side, and from then onwards Table II sets out the average daily humidities recorded by the four hygrometers.

The points brought out by this table are (i.) the humidity at 13 feet above floor level tends to be slightly greater than that at 25 feet, suggesting that air movement laterally does not persist for more than a few feet up from the floor. The small difference between the two levels may be explained by the fact that the top hygrometer is nearer to the roof ventilators, and so is slightly affected by air movement set up by them. (ii.) The humidity of the air at 13 feet and upwards is greater than that at floor level. (iii.) The average daily humidity of the air outside the shed is greater than that inside the shed. The charts from the hygrometer outside the shed showed a greater range of humidity values than do those inside the shed, an interesting feature being that during the nights a humidity of 94 to 100 is usually recorded.

As an instance of the maintenance of a difference in humidity between the air in the shed and that outside, the records of December 7th form a good example. Rain had fallen overnight and there was a fine drizzle during the morning. The humidity values given by the different hygrometers for this day were as follows :—

	4 a.m.	8 a.m.	Noon.	4 p.m.	8 p.m.	Mid-night.	Aver-age.
No. 1 25 feet above ...	89	89	90	89	89	89	89.1
No. 2 13 feet above ...	90	90	85	85	94	94	89.6
No. 3 floor level ...	79	84	79	79	89	89	83.3
No. 4 outside landward...	100	100	89	94	100	100	97.1

Average of 1, 2 and 3 = 87.1.

The various records obtained during the investigation form an interesting example of the value of meteorological data generally, and particularly humidity records, and how such data may be applied to definite problems. With regard to the cacao storage-sheds at Takoradi, the question arose as to whether the air in them was unduly humid, and, if so, could such a condition be ameliorated by increased ventilation. Hygrometer records show that the sheds are not dangerously humid, and, bearing in mind the humidity values from the external hygrometers, suggest that increased ventilation is not likely to cause improvement except by induced air movement from the eastern end of the sheds. The ventilators (louvres), at present in the roofs of the sheds, are so built that it is only winds from the northern quadrant which are likely to blow through them, and in view of the data obtained this is best orientation for them.

The extent to which a bag can mask or nullify the response of cacao in it to changes in atmospheric humidity has not been satisfactorily determined by this investigation on account of the conditions obtaining during the investigation. Further work on this problem might be planned in a store where appreciable changes in humidity could be induced and maintained.

SUMMARY.

This investigation has brought out the following points :—

(1) This particular shed may be considered to be safe for storing cacao.

(2) The data obtained support Dade's theory that cacao, having a moisture content of less than 8% and stored in an atmosphere whose average daily relative humidity is less than 82%, is not liable to deterioration during storage.

(3) The relation between the moisture content per cent. of the cacao and the relative humidity of the atmosphere surrounding it showed general agreement with Scott's curve of equilibrium for those factors.

(4) The value of meteorological records generally and their application to practical problems.

TABLE

RELATIVE HUMIDITIES—READINGS

Date.	4 a.m.				8 a.m.				Noon.			
	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4
1929												
Dec. 16	—	—	—	—	—	—	—	—	68	72	71	68
,, 17	84	89	74	94	84	89	74	89	68	68	71	64
,, 18	84	89	79	94	84	84	79	94	68	76	71	68
,, 19	84	89	84	100	84	89	79	94	72	76	71	69
,, 20	84	89	79	100	89	89	79	94	72	76	71	68
,, 21	89	84	71	100	89	84	75	94	72	76	71	72
,, 22	84	84	84	100	84	89	84	94	68	76	75	68
,, 23	89	84	84	100	84	89	79	94	72	72	71	64
,, 24	84	85	84	100	89	89	84	89	76	76	75	76
,, 25	89	89	84	100	89	89	84	94	76	72	71	76
,, 26	89	85	84	100	89	89	84	100	72	76	71	72
,, 27	—	—	—	—	85	89	89	94	76	76	71	72
,, 28	89	89	89	100	89	89	89	94	72	72	68	65
,, 29	89	85	84	100	89	85	89	100	76	72	68	68
,, 30	85	85	85	100	89	90	89	100	76	72	71	72
,, 31	85	85	84	100	89	85	89	94	72	72	71	69
1930.												
Jan. 1	89	85	89	100	90	89	89	100	72	72	71	72
,, 2	89	89	89	100	—	—	—	—	76	76	71	72
,, 3	89	89	84	100	89	89	84	95	72	76	79	72
,, 4	85	89	84	100	90	89	84	100	72	76	79	72
,, 5	84	90	89	100	89	85	84	100	76	76	79	80
,, 6	89	89	84	100	89	89	84	100	72	76	75	72
,, 7	89	90	84	100	89	85	84	100	72	76	71	72
,, 8	84	90	84	100	89	85	84	94	68	76	71	72
,, 9	84	85	89	100	84	90	84	94	72	76	75	72
,, 10	89	90	84	100	89	85	84	94	76	76	71	72
,, 11	89	90	84	100	89	90	84	94	76	76	71	72
,, 12	90	90	84	100	90	85	84	94	76	72	72	72
,, 13	—	—	—	—	—	—	—	—	80	80	79	94
,, 14	89	90	89	100	89	90	89	100	68	72	71	72
Average	87.0	87.5	84.1	99.5	87.7	87.6	83.9	95.6	72.8	74.5	72.4	71.6

No. 1. Hygrometer
No. 2. ,,
No. 3. ,,
No. 4. ,,

III.

AT SIX POINTS OF TIME DAILY.

4 p.m.				8 p.m.				Midnight.			
No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4	No. 1	No. 2	No. 3	No. 4
64	68	68	58	76	80	75	72	80	85	75	84
68	76	71	65	76	80	79	80	79	85	79	89
72	72	68	61	80	76	79	80	84	80	79	94
72	72	64	65	76	80	72	80	85	85	79	94
72	72	68	68	76	76	75	85	85	85	79	94
72	72	68	76	80	80	75	90	85	85	84	100
73	69	72	72	76	80	75	89	84	85	84	100
72	72	71	64	76	76	75	85	80	80	79	94
72	76	68	65	76	80	75	85	89	85	84	100
73	73	68	72	76	80	75	85	80	85	79	94
72	69	64	68	—	—	—	—	—	—	—	—
69	69	60	68	76	76	72	85	85	85	79	100
65	69	61	62	76	80	68	85	85	85	80	90
73	73	64	69	80	76	72	85	85	85	80	90
73	69	64	65	76	76	72	76	80	80	75	89
69	69	64	72	76	76	71	76	85	80	79	95
73	72	64	68	80	76	71	85	85	85	84	100
72	76	72	72	85	80	80	85	90	85	84	95
72	72	71	72	80	76	80	90	85	85	84	100
72	76	75	68	80	85	80	90	85	90	84	100
72	72	75	76	80	85	80	90	85	90	84	100
72	80	71	80	80	76	75	90	85	90	84	100
68	72	68	68	80	85	79	90	85	90	84	100
72	72	68	76	80	80	79	90	85	85	84	94
76	72	68	68	80	85	75	90	85	85	79	100
77	71	72	65	80	80	80	90	85	85	80	94
73	73	72	65	80	80	76	90	90	85	80	100
77	73	68	69	80	80	80	90	85	90	85	100
76	76	71	80	85	85	79	95	85	90	84	100
69	72	72	72	80	80	80	95	85	90	84	100
71.7	72.3	68.3	68.6	78.7	78.8	76.0	86.1	84.5	85.5	81.3	96.2

25 feet above.
13 feet above.
at floor level.
outside landward.

PAPER No. VI.

THE SIZE OF CACAO FARMS IN ASHANTI.

By A. C. MILES.

For many years little if anything has been known about the total acreage of cacao in the Gold Coast, or the approximate area cultivated per farmer. In 1922 the acreage was estimated to be 750,000, and the average area per farmer 3½ acres. The estimates were made without any attempt at surveying the cacao-growing localities, and were based on knowledge of the country and the quantity of cacao alleged to be produced by farmers in various sections of the cacao area. It was assumed that production per farmer amounted to twenty-five or twenty-six loads (about 14 cwts.), and that the yield per acre was between seven and eight loads per annum (about 4 cwts.).

During the past seven years the total area under cacao has been increased appreciably, and it is known that the acreage per farmer has been extended. Recent estimates suggest the total acreage to be 900,000, and the average area per farmer about 6 acres, with an annual production of about 5 cwts. per acre or 30 cwts. per farmer (*see* Paper No 1, Year-Book, 1928).

It must be understood that the collection of definite reliable data on which to base accurate calculations is almost impossible. Apart from the difficulties and amount of labour entailed in an organised survey, the farmer is naturally suspicious about giving information and strongly resents the use of measuring implements. Thus information is not easily obtainable, and, under the circumstances, estimates are subject to a wide margin of error.

In 1925–26, while the field campaign in connection with the "Plants (Injurious Pests) Ordinance" was being carried out, the opportunity occurred for collecting a wealth of data relating to cacao production in various parts of the country. Under this Ordinance provision was made for every cacao farm to be inspected, cleared, and the trees treated for pests.

In Ashanti the field campaign was started in the Bompata Division of the Ashanti-Akim District, the reason for choosing this locality being that cacao was introduced to Ashanti, by way of the S.E. border, from Akim (and rapidly spread westwards); thus the trees in the Bompata Division were known to be the oldest and most in need of expert attention.

The campaign was carried out on an organised basis in a section of the district comprising the cacao-growing areas of Konongo, Patriensa, Juansa, Bompata, Adomfe and Juaso. These centres, connected by a road system, outline a block of land roughly trian-

gular in shape and covering an area of approximately 65 square miles. Every cacao plot within the area was given treatment, and details of each were recorded by the Inspector of Plants in charge of the centre. It will thus be seen that details were collected over a sufficiently wide field to provide evidence which may with confidence be used for future estimates concerning the cacao industry in that district.

The data when analysed provide the following facts :—

Area covered by campaign	=	65.32 sq. miles.
Total area of farms treated	=	3,027 acres.
,, population of area	=	8,035 persons.
,, number of cacao farm owners	=	1,249 ,,
,, ,, ,, farms	=	2,184 plots.
,, ,, male farm owners	=	971 persons.
,, ,, female farm owners	=	278 ,,
Average area per farmer	=	2.4 acres.
,, ,, male farmer	=	2.8 ,,
,, ,, female farmer	=	1.13 ,,
,, number of plots per farmer	=	1.7 plots.
,, acreage per plot	=	1.38 acres.

1 acre in 14 acres within the area is planted with cacao.

Other data are recorded in the following tables :—

TABLE I.

Size of Farms.	Number of Farms.	Male Owners.	Female Owners.	Total Owners.
Acres.				
0– 0.9	1,299	359	198	557
1– 1.9	476	240	43	283
2– 2.9	192	172	20	192
3– 3.9	79	70	9	79
4– 4.9	43	42	1	43
5– 5.9	32	29	3	32
6– 6.9	21	17	4	21
7– 7.9	13	13	—	13
8– 8.9	7	7	—	7
9– 9.9	7	7	—	7
10–10.9	1	1	—	1
11–11.9	4	4	—	4
12–12.9	2	2	—	2
13–13.9	—	—	—	—
14–14.9	1	1	—	1
15–15.9	1	1	—	1
16–16.9	—	—	—	—
17–17.9	1	1	—	1
18–18.9	1	1	—	1
19–19.9	1	1	—	1
20–20.9	2	2	—	2
21–29.9	1	1	—	1
Totals ..	2,184	971	278	1,249

TABLE II.

Number of Plots per Farmer.

Persons having		1 plot	..	..	..	795 =	$63\frac{2}{3}$%.
,,	,,	2 plots	..	..	..	232 =	$18\frac{1}{2}$%.
,,	,,	3 ,,	..	..	..	106 =	$8\frac{1}{2}$%.
,,	,,	4 ,,	..	..	..	48 =	4%.
,,	,,	5 ,,	..	..	..	32 =	$2\frac{1}{2}$%.
,,	,,	6 ,,	..	..	..	16 =	$1\frac{1}{4}$%.
,,	,,	7 ,,	..	..	..	9 =	$\frac{3}{4}$%.
,,	,,	8 ,,	..	..	..	7 =	$\frac{1}{2}$%.
,,	,,	9 ,,	..	..	..	1 =	$\frac{1}{12}$%.
,,	,,	10 ,,	..	..	..	2 =	$\frac{2}{12}$%.
,,	,,	11 ,,	..	..	..	1 =	$\frac{1}{12}$%.

Of the total area under cacao, 2,713 acres are owned by males and 314 acres by females. The size of farms ranged from fractions of an acre to 27 acres ; approximately 60% were less than one acre, and a further 20% were less than two acres. It will be seen that 22% of the total farm owners are females and that 71% of their farms are less than one acre.

The total population of the area, as recorded for the 1921 Census, was 8,035, and 60% were classified as adults ; thus showing that 26% of the latter were cacao producers. The percentage of farmers per thousand of population compares favourably with Western Ashanti areas which were surveyed during 1928–29.

Unfortunately we have no data relating to yields from the area under review. During the campaign it was not possible to record yields, as in many farms the trees were so infected as to call for drastic treatment, which curtailed cropping for a year or more.

The information given above would not at first appear to lend confirmation to the estimates referred to in the opening paragraphs, but it must be remembered that Ashanti Akim differs from other districts in that it is comparatively new. The people are not as well settled in the Bompata Division as in older states ; thus planting has been spasmodic, and there is a high percentage of small plots. The production per thousand of population for the division is known to be low, and is in a district that has a limited output. If similar data were procured in a district more favourably situated, where divisions have utilised most of the land for cacao cultivation, it is evident that the estimates referred to might show as wide a margin of error on the conservative side.

PAPER No. VII.

SURVEY OF CACAO AREAS—WESTERN PROVINCE, ASHANTI.

By J. C. MUIR.

During the major crop season 1928–29 a survey of the cacao industry in the Province was carried out, with the object of determining the amount of cacao being produced in each district and of assessing the quantity likely to be available within the next few years.

CACAO GROWING REGION OF WESTERN PROVINCE OF ASHANTI.

The bulk of the cacao produced in the Province is grown in Sunyani and Ahafo Districts, Wenkyi and Kintampo Districts producing relatively small quantities. The four districts are of interest in so far as they represent the most northerly limits of cacao cultivation. With the exception of Ahafo, which falls entirely within the "Equatorial Zone," the other districts are partly in the "Equatorial" and partly in the "Sub-Equatorial Zones." According * to Chipp's classification, Ahafo District is placed in the "Guinea Zone," while in Sunyani, Wenkyi and Kintampo Districts the "Guinea" and "Sudanese" Zones are both represented, the Sudanese occupying the bulk of the Wenkyi and Kintampo Districts.

Auchinleck † has classified the climatic zones according to the degree of wetness recorded at each station, and, using this classification, the "Dry," "Wet," and "Medium" groups would be represented in each district.

The northerly limits to which the cacao industry is likely to expand may be shown in a general way by lines linking Pamu (in the extreme west), and extending east by north-east to Berekum, and Tanosu, thence south-east to Mampong. These lines also serve to indicate the northerly limits of the Guinea Zone, which in Ahafo consists of evergreen forest and deciduous forest, while in Sunyani District evergreen, deciduous and transition forests occur. In Wenkyi and Kintampo Districts no evergreen forest occurs, the southern portion of each district being covered by deciduous and the

* "Forest Handbook," T. F. Chipp, Gold Coast.
† "Rainfall of Gold Coast," Bull. No. 2, Dept. of Agriculture.

northern portion by savannah. Cacao cultivation is carried out in Wenkyi and Kintampo to a not inconsiderable extent north of the general boundaries indicated, in situations where deciduous forest persists as fringes in watered valleys and along the base of hill ranges, notably the Pamu-Berekum range and Tekiman-Kintampo heights.

ROCKS AND SOILS.

In the north-east of the cacao belt (Wenkyi and Kintampo) the underlying rocks are generally sediments, but intrusive and metamorphic rocks occur in the Tekyim-Kintampo range and in other hill masses. Soils from the same parent rocks vary widely in depth and physical character, due to differential rainfall conditions, which are the most important weathering agents in the tropics.

Cacao is grown at the bases of these hills and in other areas where forest of sufficient density occurs. In the north-west part of the cacao belt of Western Ashanti sedimentary rocks, metamorphic rocks, and acidic intrusives are common ; while in the south and south-west basic and ultrabasic intrusives abound. In the Sunyani and Ahafo-Goaso areas three main soil types can be distinguished, the first consisting of reddish sands or gravels, dark brown in colour when well supplied with organic matter. The red subsoil of this contains large quantities of ironstone, pebbles and quartz, and is very prone to pan formation. This type occurs frequently in the northern part of Sunyani District, and is of low productivity.

The second, more commonly found in the stream and river valleys, particularly of the Tano and Bisa, is a deep rich alluvium, brown in colour, which merges into grey-brown or grey subsoil of considerable depth, and is of high productivity.

The third type, consists of a deep, rich red lateritic loam, which extends in a broad band from Tekyimentia south-west towards Acherensua. This soil, which overlies the basic and ultrabasic intrusives of a post * Birrimian series, is highly productive, and on it is established the most dense part of the Cola belt of Western Ashanti.

These three soil types occur in the deciduous forest, referring to which Chipp states : " The character and depth of soil do not appear to be responsible for any difference in the composition of the forest." While this appears to be the case, cacao responds markedly to soil variation, both in respect to its longevity and to its yielding capacity.

RAINFALL AND RELATIVE HUMIDITY.

The rainfall of the Western Province of Ashanti varies between 45 and 70 inches, the lower precipitation occurring in the north and

* " Atlas of Gold Coast," Geological Map.

north-western parts of Sunyani, and the higher on the exposed Kintampo scarp. Of more importance, perhaps, than the actual rainfall, in the district under review, is the severity of the *harmattan*, which is of from two to three months' duration, and frequently causes defoliation of cacao trees along the northern portion of the cacao belt. As a result of this annual drought, generally extending from December to the latter end of February, no minor season crop of cacao is obtained. Kintampo and Wenchi Districts are divided into two parts, consisting of grass country in the north and deciduous and transition forests in the south, the dividing lines being a series of hill ranges. There is little protection from the dry *harmattan* wind in the northern fringes of the forest, and cacao persists only in those places where protection is afforded by the shelter of hills and in stream valleys.

The desiccating effect of the *harmattan* becomes progressively less pronounced towards the southern end of the Province, and this is reflected in the cacao of Ahafo District, which is from two to three weeks earlier than that in the northern portion of the belt. To counteract the effect of the *harmattan*, and to maintain humid conditions in the north-east of the Sunyani cacao belt, it is suggested that the Forest Reserve at Bawku (Sunyani) might be extended eastwards towards Tanosu (Wenkyi).

AGE OF THE OLDEST FARMS IN THE PROVINCE.

In the Tano valley, and in the deep red loam around Tekyimentia, cacao farms established twenty years ago may be seen flourishing despite a minimum of cultural attention. On the other hand, in the northern part of Sunyani District and in Wenchi and Kintampo may be seen numerous examples of cacao farms between ten and twelve years of age, in which the trees are becoming stag-headed and stunted. These are declining in productive capacity owing to unsuitable environmental factors, such as shallow soil, low rainfall, and severe *harmattan*. It seems highly probable that north of a line joining the towns of Pamu-Sunyani and Sunyani-Tanosu (Wenchi) there will be no large-scale expansion of a long-lived cacao industry, although in a few favoured sites suitable conditions for cacao farms are to be found.

METHOD OF OBTAINING INFORMATION RELATING TO PRODUCTION.

In each cacao-producing village in the Province a house-to-house visit was made and records as to the number of residents ; number with fruiting cacao ; number with non-fruiting cacao ; and average production of cacao per annum in loads of 60 lbs. were obtained. This information relating to population and production of cacao for the four districts of the Western Province of Ashanti is summarised in Table I in the Appendix.

SOURCES OF ERROR.

It was realised that information would not invariably be accurate, owing, firstly, to the natural suspicion of a primitive people to provide information which they feared might be used as a basis for taxation ; and, secondly, to a general tendency to state production of cacao in round numbers. It became necessary therefore to obtain some check on figures obtained direct from individuals, and this was done by recording the weight and origin of cacao transported past Bechem, Teppa and Tanosu, the main exits from Sunyani, Ahafo and Wenchi Districts respectively (*see* Map). No check was made of cacao leaving Kintampo District.

CHIEF BUYING ZONES IN SUNYANI DISTRICT.

In subsidiary buying centres, where African brokers operate, cacao is generally sent forward to the nearest large collecting centre before being transported to Kumasi. Thus cacao from Pamu, Berekum, etc., is frequently unloaded at Sunyani. In checking produce through the exits referred to above, it was found in many cases that lorry drivers were unaware of the original source of the cacao they carried.

There are three principal collecting centres in Sunyani District, namely, Sunyani, Nkwanta and Bechem. These centres serve the northern, central and southern cacao areas respectively, and it was found convenient to keep data for each of these sections distinct for the purpose of obtaining data from which to prepare a map.

INCREASE IN POPULATION SINCE 1921 CENSUS.

Referring to the totals in Table I, it will be observed that in Sunyani District the population of the cacao-growing areas alone exceeds the population of the whole district, as recorded at the 1921 Census, the figures being as follows :—

Population of Cacao-growing Villages, Sunyani District, 1928 Survey.	Total Population of Sunyani District, 1921 Census.
43,143	36,672

The increase is attributable to immigration of cacao growers from less favoured localities, from other districts, and to natural increase. In addition, there is reason to believe that it is partially due to understatement of the population at the 1921 Census.

In Ahafo District all villages fall within the cacao belt, and the population given in Table I represents the total population. This shows an increase of 4,047 since the 1921 Census was taken, the figures being as follows :—

Population recorded at 1928 Survey.	Population recorded at 1921 Census.
13,303	9,256

The increased population in this district may be attributed to the same reasons as those given for Sunyani.

In Wenchi and Kintampo the bulk of the population lies outwith the limits of the cacao-growing belt, the population of the cacao-growing villages of these districts being 17,919 and 8,898, or approximately 46% and 31% respectively of the total populations of these districts as recorded by the 1921 Census Records.

PRODUCTION IN LOADS PER FARMER OF FRUITING CACAO.

From the figures in the appended tables the production in loads of 60 lbs. per farmer of fruiting cacao is found to be as follows :—

Sunyani.			Ahafo.	Wenchi.	Kintampo.
I.	II.	III.	IV.	V.	VI.
29.95	53.57	52.12	36.97	23.91	25.60

Such figures for comparatively undeveloped districts would appear to be high but for the fact that until recently, when transport facilities to Kumasi were vastly improved, cacao growing tended to be a family rather than a personal form of occupation. This phase of the industry is unfortunately in process of changing, and at present there is an increasing tendency for individuals of a family to make their own farms and to employ labour which is deplorably inefficient and is seldom supervised. This is resulting in lack of attention to ordinary sanitation measures, such as removal of diseased pods and branches, and to the improper fermentation of cacao

The large proportion of female farmers per thousand of population—

Sunyani.	Ahafo.	Wenchi.	Kintampo.
76.5	91.3	26.7	6.7

who are notoriously careless in the preparation of their produce, is responsible for a noticeable percentage of poor quality cacao, and

in this connection it is of interest to record that in several villages of the Berekum Division females are not allowed to possess cacao farms.

MEAN YIELD PER ACRE AND MEAN SIZE OF FARM (FRUITING).

In an attempt to obtain mean yields per acre several farms were measured and the stated yields recorded. Unfortunately this gave rise to misunderstanding as to the motive, and measurements had to be abandoned. The only alternative was to assess the yield per acre by comparing the apparent productivity of the cacao in the four districts with the Amelonado to be seen at Kumasi Experiment Station. That grown in Kintampo-Wenchi and the northern parts of Sunyani appeared to fall short of the former, which averaged annually 511 lbs. per acre for the five-years period 1920–25. On the other hand, the apparent productivity of cacao in the south of Sunyani and in the Ahafo-Goaso District appeared to be considerably greater than that at Kumasi, so, in absence of reliable information, the Kumasi yield of approximately 4½ cwts. per acre has been taken as an average for the Province. At this figure the mean acreage represented by the mean production per farmer of fruiting cacao would be as follows :—

	Sunyani.			Ahafo.	Wenchi.	Kintampo.
Section.	I.	II.	III.	IV.	V.	VI.
Mean production per farmer of fruiting cacao...	29.95	53.57	52.12	36.97	23.91	25.60
Acreage at 4½ cwts. per acre	3.51	6.38	6.21	4.40	2.85	3.05

Cacao cultivation started along the old trade route through Sections II and III of Sunyani District, and from there spread through the Province. The smaller unit in Section IV is due to remoteness from this route, and in Sections I, V and VI to adverse agricultural conditions, of which low rainfall and severe *harmattan* are the most important.

PROPORTION OF POPULATION ENGAGED IN CACAO GROWING.

The total number of farmers engaged in cacao cultivation in each district can be obtained from Table I, the number per 1,000 of the population being set forth in the following table, along with the number in possession of fruiting cacao.

	Sunyani.	Ahafo.	Wenchi.	Kintampo.
Cacao farms per 1,000 population	251.4	256.5	192.8	197.7
Farmers with fruiting farms per 1,000 population ...	145.5	138.7	91.4	64.4

At present the proportion of non-fruiting to fruiting farms is estimated at three to one in Sunyani and Ahafo, and at two to one in Wenchi and Kintampo, so that within a short period the production of the Province will have approximately quadrupled, while the number of farmers with fruiting cacao will only be approximately twice the present number.

In other words, the mean production per farmer will be twice the present figure.

ACCURACY OF CENSUS RETURNS OF PRODUCTION AS COMPARED WITH GATE-CHECKED TOTALS.

In each of the three sections of Sunyani District, and in Ahafo and Wenchi, taken separately, the difference between census and checked total expressed as a percentage of the former amounted to −27.3%, −3.8%, +13.6%, +33.5% and −7.8%. Taking the Province as a whole, the quantity of cacao reported to pass the checking stations aggregated to 9,570 tons, while the amount actually recorded was 9,058 tons, a deficit of 512 tons, or −5.4% of the census figure. A minor amount of this is probably due to failure of temporary officers to record all cacao transported past their stations by night, and to the fact that some firms used 150 lbs. bags instead of the usual 140 lbs.

When this was discovered it was impossible to make any adjustment, as the produce of individual firms was not recorded separately.

Taken section by section, the bulk of the discrepancy between census and gate totals is most likely due to seasonal variation in yield, the sections showing variation from the census figures being those on the northern fringe of the cacao belt, which suffered from severe dry season previous to the survey. It is highly probable that this would affect the following crop.

MAP SHOWING TONNAGE OF CACAO IN WESTERN PROVINCE, ASHANTI.

From the data obtained in the course of the survey the attached map has been prepared. This shows the distribution and tonnage of cacao in Sunyani-Ahafo and Wenchi Districts, and the distribution only in the case of Kintampo District. The distribution of the crop is shown in brown; each 100 tons of cacao is represented by a dot, the total tonnage shown on the map being the quantity actually recorded at the checking stations. It should be unnecessary to state

that the brown shaded area does not represent a uniform stand of cacao, but marks the area throughout which cacao is the most important economic crop. The uncoloured area, which extended westwards from the boundary of the coloured area to the (French) Ivory Coast, is suitable for cacao cultivation, but is at present untouched and sparsely populated.

CONCLUSION.

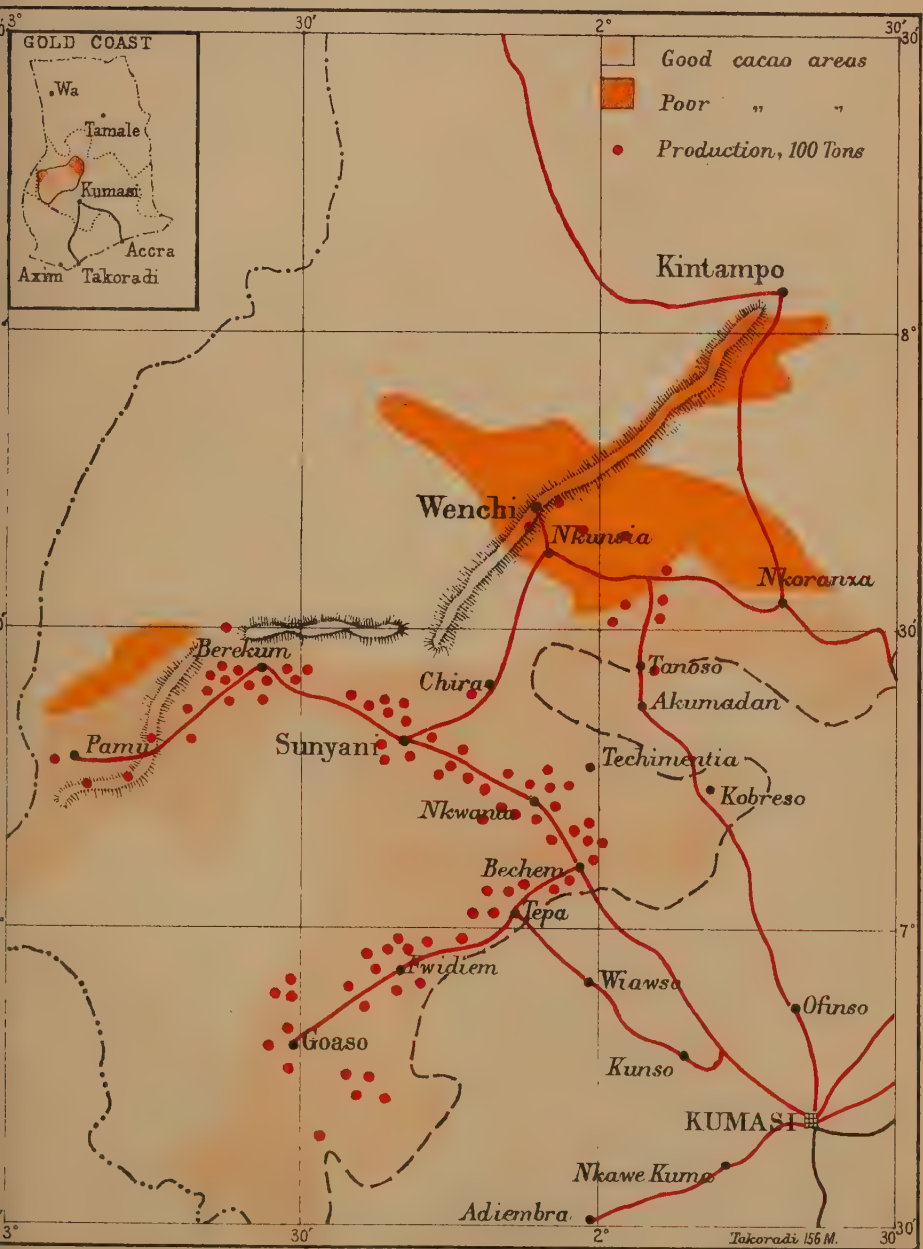
While the accuracy of the census returns as compared with the gate-checked totals is satisfactory for the Western Province as a whole, it must be admitted that the discrepancy between census and checked totals, taking each section by itself, was in some cases so great that it cannot be suggested that a census of production in the absence of checks would be entirely satisfactory over a small area.

When the total amount of produce from any area is the main object to be determined, it can be obtained by recording at suitable points the weight of produce in transit to market. The total quantity can then be re-allocated to its source of origin by an officer with some knowledge of the area being dealt with.

CACAO SURVEY—WESTERN ASHANTI. SUMMARY OF CENSUS AND GATE CHECK FIGURES.

Western Province of Ashanti Cacao Survey.		Sunyani.				Ahafo Goaso.	Wen-kyi.	Kin-tampo.
		Section I.	Section II.	Section III.	Total.			
No. of compounds ..		3,646	956	768	5,370	1,384	2,182	1,088
Population	Adults ..	15,402	4,428	3,267	23,097	8,382	9,761	4,804
	Children	13,209	3,845	2,997	20,051	4,911	8,158	4,080
	Total ..	28,611	8,273	6,264	43,148	13,293	17,919	8,884
Cacao farmers	Male ...	5,354	1,224	1,187	7,765	2,129	3,184	1,702
	Female ..	2,041	678	582	3,301	1,215	478	57
	Total ..	7,395	1,902	1,769	11,066	3,344	3,662	1,759
Farmers with fruiting farms	Male	3,069	865	874	4,808	1,454	1,485	562
	Female	577	315	287	1,179	482	162	11
	Total ..	3,646	1,180	1,161	5,987	1,936	1,647	573
CENSUS	Alleged production in loads (60 lbs.) ..	152,793	64,069	57,640	274,502	66,297	39,233	14,669
	Amount not passing checks ..	—	7,000	15,742	22,742	—	—	—
	Amount said to pass checks ..	152,793	57,069	41,898	—	—	—	—
	(A) Net amount in tons ..	4,093	1,529	1,122	6,744	1,775	1,051	—
(B) Tons recorded at gate checks ..		2,976	1,472	1,276	5,724	2,365	969	—
A — B % ∓ ..		−27.3	−3.8	+ 13.6	—	+ 33.5	−7.8	—

MAP OF WESTERN ASHANTI
Showing
CACAO DISTRIBUTION & TONNAGE



SURVEY H. Q. ACCRA, 1930.

exports show a slow periodic increase, quite insignificant against that of cacao. The thick line represents the tonnage of cacao, and where it coincides with the height of the value column it corresponds to a value of £40 a ton. Value per ton is subjected to violent fluctuations, but the general level is practically the same.

Rate of Increase of Production.

In discussing the rate of increase Miles * used a moving five-year average and plotted a smooth curve. The annual period used was the calendar year. Since publication, a crop-year from October to September has been adopted, and the seasonal figures shown graphically in Plate II. The smooth curve used is the line of nearest fit. By joining up the points representing the export figures the two-year periodicity is clearly marked.

Monthly Distribution of Exports.

The total monthly exports, from the ports and over the Eastern Frontier, are given in Table III, and graphically in Plate III.

For analytical purposes the four-month period, June to September, is used for assessing the minor crop. From the graph it will be seen that the major and minor crop peaks are quite definite in 1911–12, and that the major crop was all exported by April. There is a gradual change till 1914–15, where the minor crop appears to correspond exactly with the June-September period. After the war period (which is no criterion on account of the unsettled shipping conditions) it is evident that the major crop spread over a larger export period, and that the four months' export chosen contains some major crop cacao. This overlap is also noticed between the minor and major crop, and probably offsets the other.

The Principal Ports.

Table IV gives the export tonnage from 1900 to 1928–29 for the six chief ports. Ada, which held the second position until 1912, has ceased to function as a cacao port, the cacao now going to Accra by road. Of the five ports, Accra still holds the premier position. In Table V the export figures are expressed as percentages, and show clearly the changes occurring in the relative importance of the ports. In 1928–29 Accra shipped 45%, Takoradi 32% and the Central Province ports, Winneba, Saltpond and Cape Coast, 21%.

Railway Tonnages.

Whilst the port figures give a general indication of the development of the industry, they do not show the distribution of production throughout the cacao country.

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* Miles, A. C., and Muir, J. C. "Curve of Increase of Cacao Production as a Means of forecasting the Magnitude of the Crop" (Paper No. V., Year-Book, 1928).

TOTAL ANNUAL EXPORTS OF CACAO.

FROM THE GOLD COAST.

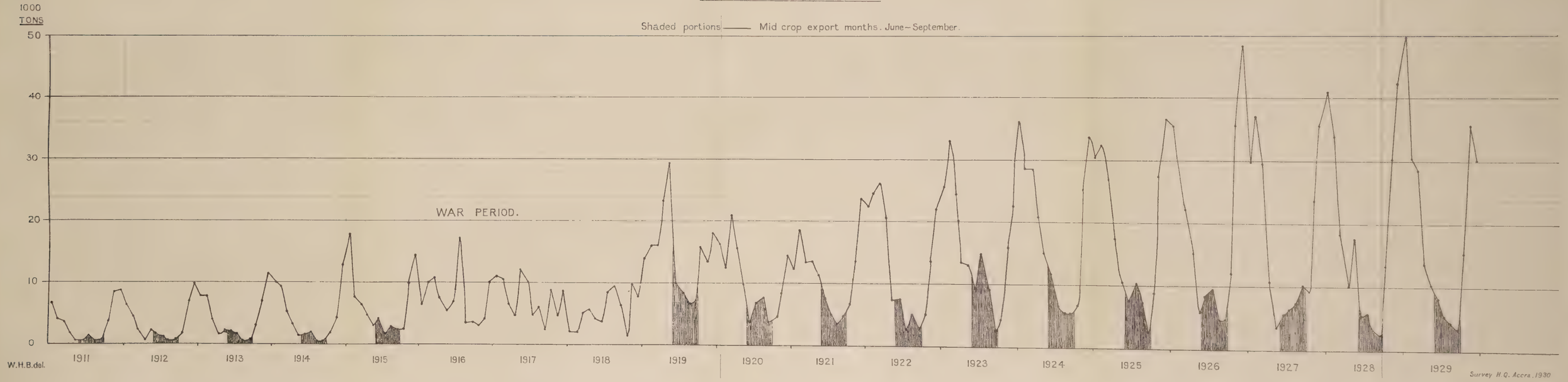
Year	Tons of Cacao
1911-12	39929
1912-13	46990
1913-14	55928
1914-15	65847
1915-16	81564
1916-17	85838
1917-18	69904
1918-19	148287
1919-20	144533
1920-21	116380
1921-22	162283
1922-23	195211
1923-24	200773
1924-25	210937
1925-26	207295
1926-27	237602
1927-28.	206983
1928-29	241822

Survey H.Q. Accra. 1930.

PLATE III

Monthly Cacao Exports.

All Ports and Eastern Frontier.



Monthly railway statements of the cacao put on rail at the various stations, and off-loaded at the termini (Accra and Sekondi/Takoradi), were supplied by the Railway Department, and from these annual tonnages for the past six seasons are given in Table VI. The list of stations chosen are distributed over the railway system. The decrease or increase in tonnage is not a direct measure of the production however, as in many places cacao comes from a large area in virtue of feeder-road construction, whilst in others road competition affects the railway receipts.

The cacao off-loaded at Accra corresponds almost exactly with the Eastern Province railway receipts, whilst Sekondi/Takoradi receives the Western Province, Central Province, and most of the Ashanti railings. The railway freight-charge datum-line coincides roughly with this division. It will be noticed that slightly less cacao is received at the termini than is put on rail, the difference being due chiefly to cacao off-loaded at intermediate stations.

The season chosen is from September to October, one month in advance of that used for port shipments, the lag representing the time from being put on rail to shipment.

The percentage figures given in Table VIII are interesting in that they show the absence of minor crop railings at some Ashanti stations and generally represent the distribution in the districts.

Estimating the Cacao Crop.

In preparing cacao prospect reports concise tables, such as IX and X, have been found most useful.

In Table IX the monthly tonnages are given for the ports and railings for the last four years, and in Table X those figures are shown as cumulative totals. It can be seen at a glance how the railway and export tonnage to date compares with the past four years' figures

Production and Consumption.

The world production and consumption is shown graphically in Plate IV. The repeated crossings of the graphs are due to the fluctuating stocks held in consuming countries in December of the various years. The last two years show a widening of the gap, due to the large increase of stocks held both in Europe and America. The obvious conclusion is that world-production is overrunning consumption, but certain factors need to be taken into consideration. The cacao industry is entering into a stage when big deals are carried through with the product on the home markets, and accumulation of stocks may be due to building up reserves, particularly in America, against an expected increase in demand as a result of advertising, by certain manufacturing groups, in the ordinary competition of business.

TABLE I.

World Cacao Production.

In tons of 1,000 *kilos.* (*From the "Gordian"*).

Year.	Gold Coast.	Nigeria.	San Thomé.	Kamerun.	Togo-land.	Fernando Po.	Ivory Coast.	Mada-gascar.	Bel-gium Congo.	Others.	Africa.	America.	Asia and South Seas.	World.
1911 ..	40,356	4,471	30,453	3,582	236	2,806	15	46	681	200	82,846	150,602	6,349	239,797
1912 ..	39,260	3,463	35,512	4,672	283	2,229	21	60	845	200	86,545	137,788	6,803	231,136
1913 ..	51,309	3,679	35,311	5,265	335	2,824	47	39	914	200	99,923	146,474	6,989	253,386
1914 ..	53,735	5,018	32,064	3,200	450	3,144	36	46	482	200	98,375	173,264	5,453	277,092
1915 ..	78,514	9,260	29,617	3,400	457	3,866	114	115	620	200	126,163	163,412	6,863	296,438
1916 ..	73,205	9,099	33,336	4,330	431	3,804	186	85	770	200	125,446	164,842	6,591	296,879
1917 ..	92,419	15,689	30,882	4,105	1,572	3,747	319	78	784	300	149,895	191,642	7,181	348,718
1918 ..	67,404	10,383	17,332	2,575	1,576	4,220	420	81	743	300	105,034	162,792	6,460	274,286
1919 ..	178,973	26,121	49,945	[illegible],141	2,851	3,412	960	122	835	300	267,660	195,458	7,008	470,126
1920 ..	126,596	17,429	21,471	4,112	2,627	4,741	1,036	99	355	300	178,766	190,580	5,853	375,199
1921 ..	133,909	18,473	28,276	5,859	1,875	5,199	1,486	92	604	400	196,173	191,370	6,149	393,692
1922 ..	158,771	31,754	18,577	6,740	3,505	4,536	2,363	159	660	400	227,465	175,555	7,587	410,627
1923 ..	197,234	33,347	12,786	5,132	3,325	7,209	3,600	101	687	500	263,921	186,767	5,771	456,459
1924 ..	222,279	37,799	24,934	7,710	6,432	9,637	4,299	134	834	500	314,558	185,826	8,092	508,476
1925 ..	216,684	41,725	18,483	7,857	4,607	5,965	6,278	157	779	942	303,477	184,154	7,034	494,665
1926 ..	229,537	36,573	13,931	7,778	5,226	5,765	6,837	123	850	848	307,468	163,241	7,054	477,763
1927 ..	208,349	36,670	14,432	10,116	6,314	6,421	9,808	146	837	957	294,050	186,255	8,312	488,617
1928 ..	223,339	46,592	15,581	10,148	6,317	8,555	14,515	152	850	711	326,760	180,195	7,430	514,385
1929 ..	—	—	—	—	—	—	—	—	—	—	—	—	—	533,800

Cacao Production & Consumption.

Plate IV.

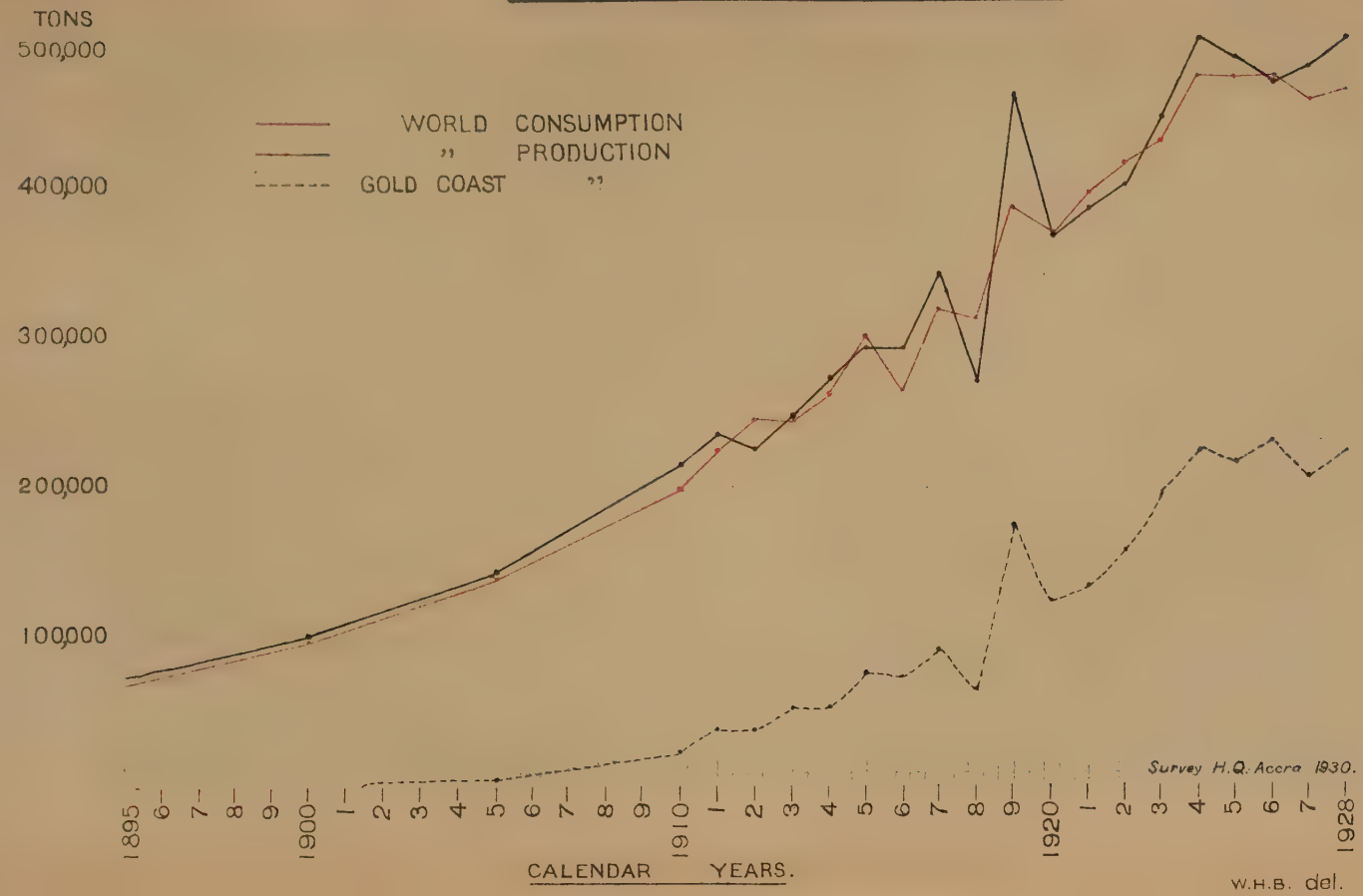


TABLE Ia.

PRODUCTION AS PERCENTAGE OF AFRICAN TOTAL.

	Gold Coast.	Nigeria.	Ivory Coast.
1911	49	5	—
1914	55	5	—
1917	62	10	—
1920	70	10	·5
1923	75	13	1·5
1926	75	12	2
1927	70	13	3
1928	69	14	4

TABLE II.

Chief Agricultural Exports.

Gold Coast.

Weight in Tons, First Column. Value in £1,000, Second Column.

Year.	Cacao.		Copra.		Palm Kernel.		Palm Oil.		Rubber.	
1903	2,279	86	282	3	13,194	146	10,358	146	1,008	197
1904	5,112	200	221	3	10,967	87	8,947	129	1,792	361
1905	5,093	187	251	3	9,781	79	6,393	88	1,622	234
1906	8,975	336	327	4	9,355	81	8,576	125	1,629	335
1907	9,356	515	386	6	9,753	102	9,472	119	1,585	333
1908	12,744	540	612	6	8,956	78	9,013	130	792	168
1909	20,213	755	809	10	11,598	112	8,029	103	1,234	264
1910	22,631	867	755	13	14,182	185	8,180	161	1,443	359
1911	39,726	1,413	779	13	13,254	176	6,441	129	1,191	219
1912	38,647	1,643	620	12	14,628	205	5,778	113	889	169
1913	50,554	2,489	629	14	9,744	159	3,441	66	588	88
1914	52,888	2,194	656	12	5,633	89	1,983	38	292	22
1915	77,278	3,651	770	13	4,064	51	1,324	26	289	25
1916	72,123	3,846	633	14	5,857	86	1,801	38	989	79
1917	90,964	3,147	736	20	4,768	75	796	25	1,322	110
1918	66,343	1,797	99	3	8,933	153	2,683	84	621	57
1919	176,155	8,278	983	30	9,892	253	3,754	140	322	34
1920	124,773	10,056	427	18	7,664	225	2,518	114	134	27
1921	133,195	4,764	443	10	1,650	31	270	8	46	7
1922	159,305	5,842	1,102	21	3,155	46	841	20	7	½
1923	197,664	6,567	1,660	37	3,757	57	1,520	38	140	9
1924	223,329	7,250	1,163	27	6,592	111	1,350	36	122	9
1925	218,151	8,222	1,324	31	6,569	115	1,423	44	490	34
1926	230,840	9,181	1,513	33	7,659	126	1,752	52	633	53
1927	209,910	11,728	1,454	31	6,545	107	1,090	30	318	31
1928	225,077	11,230	1,454	32	6,214	104	502	14	254	26
1929	232,490	9,528	1,236	21	5,967	89	568	17	289	28

TABLE III

Cacao.

Total Monthly Export Tonnage from all Ports and to French Togoland.

Gold Coast.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1911 ...	6,696	4,037	3,260	1,749	851	574	1,258	689	585	3,391	8,183	8,453	39,726
1912 ...	6,131	4,768	2,231	750	2,036	1,517	1,220	567	682	1,983	6,851	9,911	38,647
1913 ...	7,843	7,838	4,041	1,675	2,127	2,022	1,484	479	736	3,260	7,921	11,128	50,554
1914 ...	10,034	9,366	5,140	3,256	1,195	1,482	1,955	519	672	2,087	4,473	12,719	52,888
1915 ...	17,297	7,778	6,298	4,952	3,003	4,304	1,713	2,835	2,398	2,460	9,995	14,245	77,278
1916 ...	6,213	10,077	10,686	7,319	5,246	6,929	1,707	3,324	3,363	2,950	4,168	10,179	72,161
1917 ...	11,067	10,603	6,606	4,790	11,947	10,065	4,951	6,059	2,453	8,958	4,861	8,604	90,964
1918 ...	2,095	2,005	5,296	5,593	4,287	3,990	8,395	9,468	6,352	1,528	9,351	7,983	66,343
1919 ...	13,594	15,912	15,993	23,287	29,089	9,676	8,496	6,481	6,897	15,509	13,351	17,891	176,176
1920 ...	16,514	12,795	21,045	15,555	9,982	4,038	6,710	7,342	3,801	4,357	8,422	14,212	124,773
1921 ...	12,220	18,793	13,188	13,274	11,108	7,819	4,937	3,596	4,454	6,831	13,425	23,550	133,195
1922 ...	22,201	24,681	26,060	20,657	7,380	7,253	2,499	4,894	2,852	5,128	13,571	22,129	159,305
1923 ...	36,783	31,854	24,514	13,281	12,911	8,895	14,732	9,016	2,397	4,899	15,642	22,740	197,664
1924 ...	35,878	28,467	28,576	20,995	14,919	11,634	6,195	5,505	5,323	6,871	25,210	33,756	223,329
1925 ...	30,534	32,255	26,671	17,622	10,697	7,156	10,401	7,344	2,420	8,997	27,210	36,844	218,151
1926 ...	35,606	27,628	22,324	15,329	5,890	8,847	9,504	4,404	4,712	12,372	35,864	48,360	230,840
1927 ...	29,274	36,973	29,767	11,242	3,649	5,604	6,350	7,740	10,407	9,414	23,769	35,721	209,910
1928 ...	41,386	33,711	18,318	10,188	17,163	5,448	5,914	3,405	2,546	13,748	30,588	42,662	225,077
1929 ...	48,997	31,075	28,377	13,868	10,573	8,284	5,605	4,323	3,719	15,928	36,460	30,853	238,062

TABLE IV.

Cacao Export Tonnage from Principal Ports. Gold Coast.

Calendar Years.

Year.	Accra.	Ada.	Sekondi.	Winneba.	Saltpond.	Cape Coast.	Other Ports and Frontier.	Total.
1900 ...	502	23	—	8	1	1	1	536
1901 ...	861	101	—	17	1	1	—	980
1902 ...	1,643	582	—	87	2	1	81	2,386
1903 ...	1,504	387	—	87	16	—	285	2,279
1904 ...	2,818	1,696	27	303	42	2	228	5,116
1905 ...	3,143	1,391	80	387	45	—	46	5,092
1906 ...	5,825	1,859	192	600	115	4	380	8,975
1907 ...	4,734	2,684	493	925	243	30	246	9,355
1908 ...	6,880	2,826	1,144	1,356	456	48	33	12,742
1909 ...	11,353	3,756	1,562	2,321	1,163	51	7	20,213
1910 ...	13,508	3,209	1,931	2,433	1,412	132	6	22,631
1911 ...	22,469	5,625	4,824	4,039	2,388	344	37	39,726
1912 ...	20,802	5,337	5,914	3,869	2,403	293	29	38,647
1913 ...	25,536	5,788	7,936	6,161	2,973	861	1,299	50,554
1914 ...	25,916	4,452	11,665	5,286	3,225	966	1,378	52,888
1915 ...	40,115	4,050	17,648	8,166	3,715	1,908	1,676	77,278
1916 ...	38,560	3,896	15,509	7,201	3,609	2,067	1,319	72,161
1917 ...	49,543	1,463	21,652	9,001	4,296	3,276	1,733	90,964
1918 ...	40,088	475	15,749	4,163	2,410	2,074	384	66,343
1919 ...	94,785	4,241	39,502	16,057	12,513	6,539	2,539	176,176
1920 ...	53,535	2,580	41,318	15,318	6,331	4,382	1,309	124,773
1921 ...	61,620	2,168	42,662	12,287	7,282	5,362	1,814	133,195
Seasonal Years. October—September.								
1922–23	86,535	2,576	57,181	22,405	9,461	8,031	9,022	195,211
1923–24	94,837	1,146	64,136	17,952	11,115	7,223	4,363	200,773
1924–25	102,196	1,307	59,930	21,182	12,163	7,950	6,209	210,937
1925–26	95,872	564	62,919	21,660	12,508	8,371	5,401	207,295
1926–27	108,180	1,082	79,440	22,836	13,707	6,756	5,601	237,602
1927–28	83,676	132	75,737	19,686	14,875	7,083	5,794	206,983
1928–29	106,625	660	76,815	25,865	17,874	7,978	6,005	241,822

TABLE V.

Cacao Exports from Principal Ports of Gold Coast.

Expressed as Percentage of Annual Exports. From Data of Table IV.

Calendar Years.

Year.	Accra.	Ada.	Sekondi.	Winneba.	Saltpond.	Cape Coast.	Rest.
1900 ..	94	4	—	2	—	—	—
1901 ..	88	10	—	2	—	—	—
1902 ..	69	24	—	4	—	—	3
1903 ..	66	17	—	4	1	—	12
1904 ..	55	33	1	6	1	—	4
1905 ..	62	26	2	8	1	—	1
1906 ..	65	21	2	7	1	—	4
1907 ..	50	29	5	10	3	—	3
1908 ..	54	22	9	10	3	—	—
1909 ..	60	14	9	11	6	—	—
1910 ..	60	14	9	11	6	—	—
1911 ..	57	14	12	10	6	1	—
1912 ..	54	14	15	10	6	1	—
1913 ..	50	11	16	12	6	2	3
1914 ..	49	8	22	10	6	2	3
1915 ..	52	5	23	11	5	2	2
1916 ..	54	5	21	10	5	3	2
1917 ..	54	2	24	10	5	3	2
1918 ..	60	1	24	7	4	3	1
1919 ..	54	2	22	9	7	4	2
1920 ..	43	2	33	13	5	3	1
1921 ..	46	2	32	9	5	4	1
Seasonal Years. October—September.							
1922–23	44	1	30	12	5	4	4
1923–24	48	—	31	9	6	4	2
1924–25	50	—	29	10	6	3	2
1925–26	47	—	31	10	6	4	2
1926–27	47	—	34	19	6	2	2
1927–28	41	—	37	10	7	3	2
1928–29	45	—	32	10	8	3	2

TABLE VI.

Railway Tonnages, Gold Coast.

Seasonal Year, September-August.

Name of Town.	1923–24.	1924–25.	1925–26.	1926–27.	1927–28.	1928–29.
Sekondi*	58,518	58,301	63,066	81,999	76,775	74,577
Insu	56	85	79	107	162	628
Buabin	8	48	68	52	87	102
Dunkwa	5,165	5,730	7,497	8,395	8,774	9,434
Obuasi	1,554	1,448	1,147	1,212	1,251	1,292
Akrokerri ...	5,587	4,975	4,676	5,112	3,478	3,497
Bekwai	9,460	8,580	8,275	12,947	11,933	12,195
Kumasi	30,431	27,146	26,474	32,384	34,269	31,695
Ejisu	2,466	3,971	4,229	6,371	6,228	6,045
Konongo	2,606	2,513	2,438	3,087	3,349	3,397
Juaso	2,195	1,857	1,694	1,777	937	1,006
Bompata	391	545	679	823	834	761
Nkawkaw ...	4,772	4,780	4,106	3,543	4,811	4,639
Anyinam	4,052	2,910	2,357	1,406	2,038	2,732
Koforidua ...	25,190	29,015	22,682	18,397	13,616	20,327
Mangoase ...	12,677	14,468	10,765	10,409	7,161	6,898
Nsawam	30,439	23,585	23,666	19,548	17,776	35,652
Accra*	93,570	84,675	73,548	65,748	55,163	80,623
C. Province ...	—	—	23	653	3,290	4,866
Ashanti	61,130	54,449	54,108	71,842	66,191	63,693
E. Province ...	89,292	87,284	75,664	65,635	54,465	80,217
W. Province ...	8,629	8,470	12,562	10,307	11,216	12,407
Railway Totals ...	159,051	150,203	142,357	148,436	135,162	161,183

* Sekondi/Takoradi and Accra refer to cacao off-loaded.

TABLE VII.

Monthly Means of Cacao Railed from Stations, Gold Coast.

In Tons.

Name of Town.	Sept.	Oct.	(Six-year period. 1923/24–1928/29 inclusive.) Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Totals.
Sekondi/Takoradi * ..	642	3,396	12,008	13,871	13,894	12,344	6,594	2,529	1,259	1,038	807	492	68,874
Insu	1	5	28	57	42	37	11	2	1	1	1	—	186
Buabin	1	3	24	17	11	4	2	—	—	—	—	—	62
Dunkwa	51	186	1,029	1,534	1,707	1,475	739	203	141	211	157	70	7,503
Obuasi	8	72	248	265	351	162	45	50	45	58	8	6	1,318
Akrokerri	47	178	709	834	941	861	512	155	24	87	13	26	4,387
Bekwai	84	580	1,734	2,029	2,006	2,034	954	571	349	116	57	54	10,568
Kumasi	412	2,191	5,881	5,633	5,043	5,065	3,080	1,407	487	472	457	273	30,401
Ejisu	24	328	963	1,091	1,113	882	390	53	10	15	6	10	4,885
Konongo	14	109	559	629	597	665	188	56	55	14	4	8	2,898
Juaso	21	40	239	384	304	333	214	21	19	—	2	4	1,581
Bompata	2	19	109	151	179	149	57	7	—	—	—	1	674
Nkawkaw	108	384	830	1,003	957	620	340	99	8	6	15	73	4,443
Anyinam	57	264	519	623	553	326	169	18	3	1	15	33	2,581
Koforidua	298	2,002	4,147	4,332	4,397	3,114	1,725	394	257	333	260	281	21,540
Mangoase	140	713	1,636	2,526	2,304	1,427	510	200	304	308	211	118	10,397
Nsawam	222	1,611	5,268	5,939	5,167	3,298	1,592	196	648	638	378	153	25,111
Accra*	1,041	5,808	14,960	17,449	15,530	10,107	4,770	1,169	1,463	1,559	989	711	75,556
W.P. Railway ..	68	259	1,717	2,275	2,459	1,883	907	301	167	279	189	95	10,599
C.P. Railway	6	68	304	318	444	233	38	4	10	25	12	12	1,474
Ashanti Railway ..	633	3,647	11,359	12,106	12,279	10,867	5,794	2,424	1,042	796	560	397	61,904
E.P. Railway	1,065	6,156	15,133	17,197	15,439	10,025	4,727	972	1,464	1,535	1,020	693	75,426
Totals	1,772	10,130	28,513	31,896	30,621	23,008	11,466	3,701	2,683	2,635	1,781	1,197	149,403

* Sekondi/Takoradi and Accra figures refer to cacao off-loaded.

TABLE VIII.

Monthly Percentage of Cacao Railed from Stations, Gold Coast.

(Six-Year Means, from Data of Table VII.)

Name of town.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.
Sekondi/Takoradi *	1	5	17	20	20	18	10	3	2	2	1	1
Insu	1	2	15	30	22	20	6	1	1	1	1	—
Buabin	1	5	39	28	18	6	3	—	—	—	—	—
Dunkwa	1	2	13	20	23	20	10	3	2	3	2	1
Obuasi	1	5	19	20	27	12	3	4	3	4	1	1
Akrokerri	3	4	16	18	21	19	12	3	1	2	—	1
Bekwai	1	6	16	19	19	19	9	5	3	1	1	1
Kumasi	1	7	19	18	17	17	10	5	2	2	1	1
Ejisu	1	7	20	22	23	18	8	1	—	—	—	—
Konongo	—	4	20	22	21	23	6	2	2	—	—	—
Juaso	1.5	3	15	24	19	21	14	1.5	1	—	—	—
Bompata	—	3	16	22	27	22	9	1	—	—	—	—
Nkawkaw	2	9	19	23	22	14	8	2	—	—	—	1
Anyinam	2	10	20	24	21	13	7	1	—	—	1	1
Koforidua	2	9	19	20	20	15	8	2	1	2	1	1
Mangoase	1	7	16	24	22	14	5	2	3	3	2	1
Nsawam	1	6	21	24	21	13	6	1	3	2	1	1
Accra *	1	8	20	23	21	13	6	2	2	2	1	1
W. Province	1	2	16	21	23	18	8.5	3	1.5	3	2	1
C. Province	—	5	20	21	30	16	3	—	1	2	1	1
Ashanti	1	6	18	19.5	20	17.5	9	4	2	1	1	1
E. Province	1	8	21	23	21	13	6	1	2	2	1	1
Railway Total	1	7	19	21	20.5	15	8	2.5	2	2	1	1

* Sekondi/Takoradi and Accra percentages refer to cacao off-loaded.

TABLE IX.

Gold Coast.

Movement of Cacao (Port and Rail).

In 100 *Tons.*

	Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Totals.
Accra	1925–26	62	124	181	145	122	108	84	28	40	35	10	22	959
	1926–27	63	157	205	128	167	146	28	25	35	29	45	54	1,082
	1927–28	56	130	145	164	122	50	27	54	24	35	15	16	837
	1928–29	85	142	181	187	136	134	44	34	44	37	18	25	1,066
	1929–30	95	148	100	128	58	99	41	86	65	—	—	—	—
Sekondi and Takoradi	1925–26	6	54	75	142	89	66	53	23	46	45	23	9	629
	1926–27	26	113	172	110	126	110	60	7	10	10	23	28	794
	1927–28	15	42	120	154	154	99	62	69	20	9	7	5	757
	1928–29	20	60	130	177	97	103	66	66	24	6	14	4	768
	1929–30	36	126	142	125	94	67	28	32	43	—	—	—	—
C.P. Ports	1925–26	20	77	99	58	59	48	16	6	2	14	11	16	425
	1926–27	29	74	88	46	67	40	22	4	11	24	8	18	433
	1927–28	23	52	81	78	56	32	11	46	10	14	11	3	416
	1928–29	28	90	102	113	66	42	26	5	14	14	11	7	517
	1929–30	25	71	53	91	36	46	25	22	20	—	—	—	—
All Ports	1925–26	88	256	357	346	273	223	153	59	88	95	43	46	2,027
	1926–27	120	345	468	284	368	297	112	36	56	63	77	101	2,328
	1927–28	85	225	346	399	332	182	100	171	54	59	34	25	2,013
	1928–29	134	294	414	480	302	282	138	105	83	56	43	37	2,369
	1929–30	156	345	296	347	191	212	95	140	129	—	—	—	—
Ashanti Railway	1925–26	19	89	131	125	77	53	15	2	15	10	4	11	551
	1926–27	66	176	160	123	90	54	16	7	5	3	6	7	714
	1927–28	38	129	134	114	136	56	17	25	5	1	—	1	656
	1928–29	39	138	128	163	124	29	7	2	2	1	2	9	645
	1929–30	84	168	160	114	52	11	15	—	13	—	—	—	—
W.P. Railway	1925–26	3	28	31	28	19	9	1	1	1	4	1	—	126
	1926–27	4	20	29	18	17	5	1	1	2	4	1	2	105
	1927–28	3	18	23	20	21	10	1	3	11	1	—	—	110
	1928–29	2	23	26	39	20	8	1	2	—	—	—	1	125
	1929–30	9	27	32	29	14	2	—	—	2	—	—	—	—
C.P. Railway	1926–27	—	—	—	4	2	—	—	—	—	—	—	—	7
	1927–28	2	8	6	9	5	1	—	—	1	—	—	—	33
	1928–29	2	10	13	14	7	1	—	—	—	—	—	1	49
	1929–30	3	10	11	11	7	2	—	—	—	—	—	—	—
E.P. Railway	1925–26	66	160	223	155	90	30	2	5	6	7	1	10	757
	1926–27	48	154	177	170	54	11	5	10	7	4	6	17	663
	1927–28	75	125	120	89	59	7	5	16	18	9	3	4	532
	1928–29	91	180	168	169	93	44	7	19	18	6	3	19	817
	1929–30	95	138	99	105	63	46	17	22	25	—	—	—	—
Railway Totals	1925–26	88	277	385	308	186	92	18	8	22	22	6	22	1,434
	1926–27	117	350	367	315	162	71	22	18	14	12	14	26	1,489
	1927–28	119	280	283	232	221	73	23	43	35	11	4	5	1,330
	1928–29	134	351	335	385	246	83	15	23	20	9	6	30	1,836
	1929–30	191	343	302	259	136	61	32	32	39	—	—	—	—

TABLE X.

Gold Coast.

Movement of Cacao (Port and Rail).

100 *Tons Cumulative Totals.*

	Year.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.
Accra	1925–26	62	185	367	511	633	741	825	853	892	927	937	959
	1926–27	63	220	425	553	720	865	894	919	953	982	1,028	1,082
	1927–28	56	186	331	495	617	667	694	747	771	806	821	837
	1928–29	85	228	408	595	731	865	909	942	987	1,023	1,041	1,066
	1929–30	95	243	344	472	530	628	669	755	820	—	—	—
Sekondi and Takoradi	1925–26	6	60	135	276	365	431	484	507	553	598	621	629
	1926–27	26	139	310	420	546	656	716	724	733	744	767	794
	1927–28	15	57	177	332	485	584	647	715	736	745	752	757
	1928–29	20	80	211	388	485	588	654	720	744	750	764	768
	1929–30	36	162	303	429	523	590	618	650	693	—	—	—
C.P. Ports	1925–26	20	97	196	254	314	362	378	383	385	399	410	425
	1926–27	29	104	192	238	305	346	368	372	383	407	415	433
	1927–28	23	74	156	234	289	321	332	378	388	412	413	416
	1928–29	28	118	220	334	399	441	467	472	486	499	510	517
	1929–30	25	95	148	239	274	320	345	367	387	—	—	—
All Ports	1925–26	88	344	701	1,047	1,320	1,543	1,696	1,755	1,843	1,937	1,981	2,027
	1926–27	120	465	933	1,217	1,585	1,883	1,995	2,031	2,087	2,150	2,227	2,328
	1927–28	85	310	656	1,056	1,388	1,570	1,671	1,841	1,896	1,955	1,988	2,013
	1928–29	134	427	841	1,322	1,624	1,906	2,045	2,150	2,233	2,289	2,332	2,369
	1929–30	156	502	797	1,144	1,335	1,547	1,642	1,782	1,912	—	—	—
Ashanti Railway	1925–26	19	108	239	364	441	494	509	511	526	536	540	551
	1926–27	66	242	403	526	615	669	685	693	698	701	707	714
	1927–28	38	167	301	415	551	607	624	649	654	655	655	656
	1928–29	39	177	305	468	593	622	629	631	632	634	636	645
	1929–30	84	252	412	526	578	589	603	603	616	—	—	—
W.P. Railway	1925–26	3	31	62	90	109	117	118	119	120	125	126	126
	1926–27	4	24	53	71	88	94	95	95	97	101	103	105
	1927–28	3	21	44	64	85	95	96	99	109	110	110	110
	1928–29	2	26	52	91	112	120	121	122	123	123	123	125
	1929–30	9	36	68	97	111	112	113	113	115	—	—	—
C.P. Railway	1926–27	—	—	—	4	5	5	6	6	6	6	6	7
	1927–28	2	10	17	25	30	31	31	31	32	33	33	33
	1928–29	2	12	25	39	46	47	48	48	48	48	49	49
	1929–30	3	13	25	35	43	45	45	45	45	—	—	—
E.P. Railway	1925–26	66	226	449	604	694	724	727	732	738	745	746	757
	1926–27	48	202	379	549	603	614	619	629	636	640	646	663
	1927–28	75	201	321	410	469	476	481	497	515	524	527	532
	1928–29	91	271	438	607	700	745	751	771	789	795	798	817
	1929–30	95	233	332	437	500	547	564	586	611	—	—	—
Railway Totals	1925–26	88	365	750	1,058	1,244	1,336	1,354	1,362	1,384	1,406	1,412	1,434
	1926–27	117	468	834	1,150	1,312	1,383	1,405	1,423	1,437	1,449	1,463	1,489
	1927–28	119	399	682	914	1,136	1,209	1,232	1,275	1,311	1,321	1,325	1,330
	1928–29	134	485	820	1,206	1,451	1,534	1,549	1,772	1,792	1,801	1,806	1,836
	1929–30	191	534	837	1,096	1,232	1,292	1,325	1,347	1,387	—	—	—

PAPER No. IX.

INTERVAL BETWEEN HARVESTING AND EXPORT OF THE CACAO CROP ON THE GOLD COAST.

By J. D. BROATCH.

An attempt is here made to determine the average time which elapses between the harvesting and the export of cacao in the Gold Coast. While such a period must necessarily vary enormously with individual lots, the bulk of the crop is hurried from the grower to the ports with as little loss of time as possible. Miles, in his "Cacao Crop Forecast, 1928–29," suggests a period of ten to twelve weeks, and favours the latter. Recent inquiries amongst traders indicated an absence of any definite idea as to the period, and the estimates given varied widely. An interesting fact, however, is that Bank loans and advances are generally made on a ninety-day basis, indicating that three months covers the time during which cacao remains in the hands of local purchasers, more especially those with limited capital.

Production of Crop.

The only available figures showing monthly yields are those from the Agricultural Experiment Stations. As these stations are scattered through the cacao-producing belt the monthly pickings recorded may be taken as fairly representative of the ripening of the crop throughout the Colony. The fact that the crop is harvested more regularly and more frequently on the stations than on the farmers' plots may be disregarded meantime.

Seasonal Distribution of Crop.

The monthly-yield figures for this comparison were obtained from the Amelonado plot records of the four chief Agricultural Stations, viz., Aburi, Asuansi, Kpeve and Kumasi. Only yields for Amelonado plots were taken, as this variety is found almost to the exclusion of all others on peasant farms. On examination of the yield-figures, and having in mind the facts regarding the seasonal distribution of the crop, it was decided that the truest results would be obtained by taking the crop-year as extending from August 1st to July 31st. Picking of the major crop usually commences in late August, and the minor crop is normally harvested by the end of June, thus the selected year includes a complete major crop and the following minor crop. The monthly yields per acre were averaged

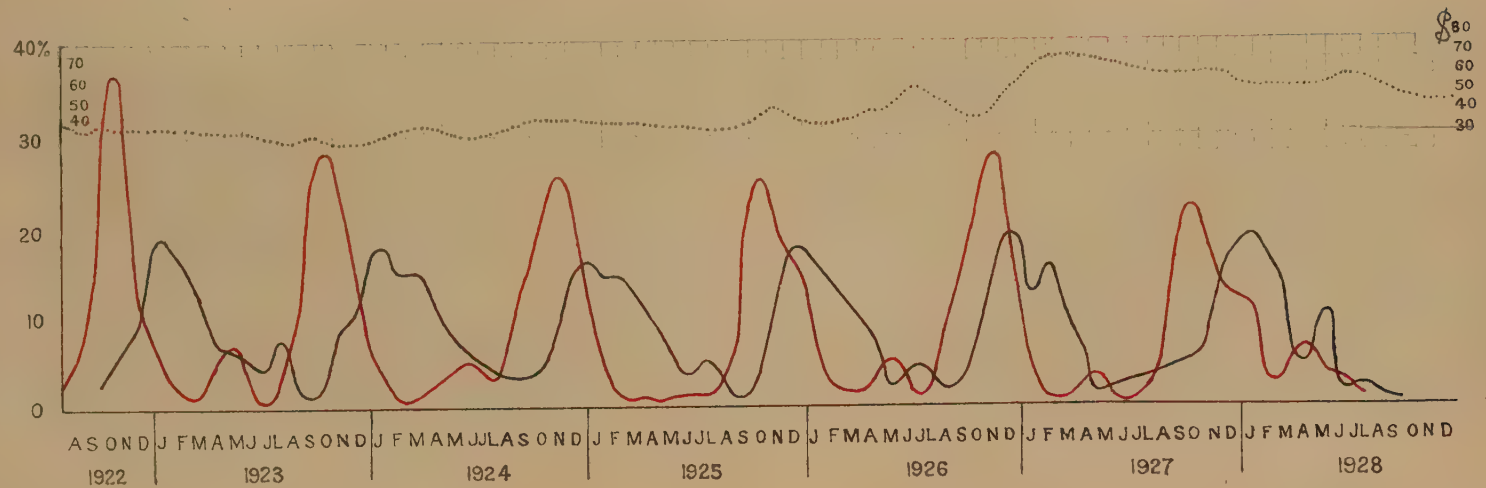
PLATE I.

LAG OF CACAO EXPORTS BEHIND PRODUCTION

— EXPORTS SHEWN AS MONTHLY PERCENTAGES OF ANNUAL EXPORTS (YEAR. OCT-SEPT) FROM OFFICIAL DATA.

— PRODUCTION " " " " " PRODUCTION (" " AUG-JULY) EXPER. STATION DATA.

--- PRICE OF CACAO PER CWT F.O.B. (LONDON QUOTATIONS)

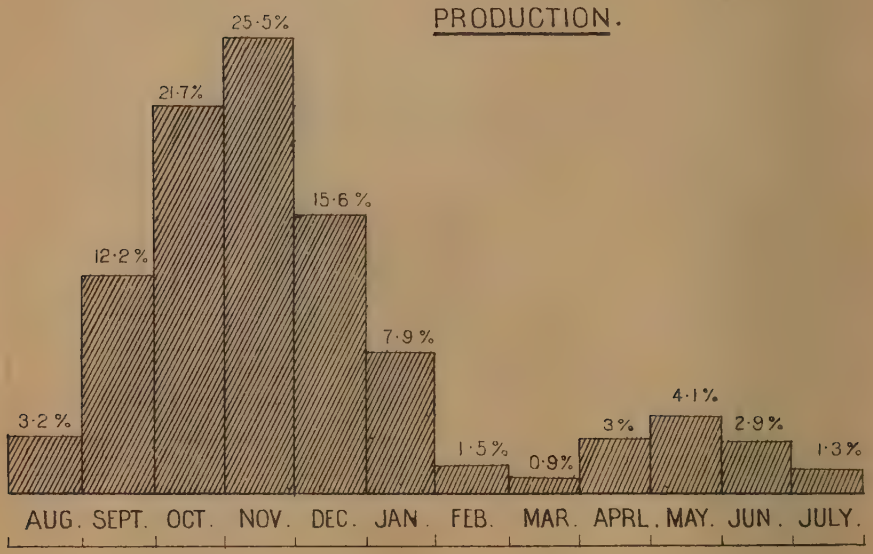


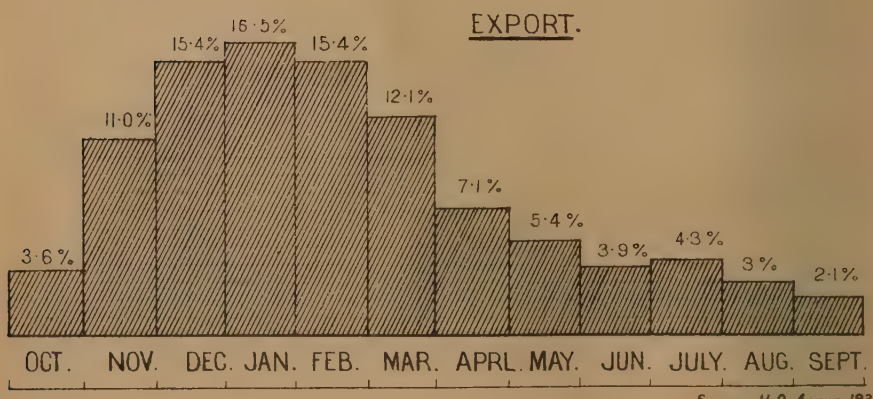
Survey H.Q. Accra, 1930.

CACAO CROP

Plate 2.

MEAN OF SIX SEASONS 1922—1928.





Survey H.Q. Accra, 1930.

for the four stations and calculated as percentages of the averaged total for the selected crop-year and graphed as shown.

Season of Export.

Monthly export figures were obtained from the Customs returns. These show that monthly shipments almost always reach a minimum in September, that is, immediately before the new major crop is available. In view of this the twelve months, October to September, were selected as being the most likely to represent truly the produce of a major and the following minor crop. Stocks in hand in the country are probably lower at the beginning of October than at any other time, and thus a fairly accurate idea may be obtained of the relation of subsequent exports to production without the masking effect of large quantities of old stock. Merchants will not, for business reasons, declare their stocks at any time. Monthly percentage exports were calculated on the selected export year (October to September) and graphed.

Curve of Production.

The curves showing production (*see* Plate I) are in close agreement with information already published on the subject.* They show that 84% of the crop is harvested during the five months, September to January (major crop season), with the maximum in October or November. The minor crop in April, May, June amounts to 9% of the total. In some years there is an appreciable percentage in August.

Curve of Export.

The export curves, while having the same general form as those for production, show a considerable degree of flattening, indicating that there are influences which tend to regulate the export of cacao and spread it more evenly over the year. The shipments for any one month never reach 20%, while production may exceed 30% of the yearly total. Even so, 71% of the crop leaves the Coast during the five months November to March with a maximum in January, the remaining 29% being spread more or less evenly over the other seven months, falling to a minimum, as has already been said, in September.

Time Between Production and Export.

Examination of the graphs shows an average lag of export behind production of two or three months. Arithmetical calculation gives the following results :—

Season.	*Lag.*
1922–23	78 days.
1923–24	92 ,,
1924–25	91 ,,
1925–26	71 ,,
1926–27	76 ,,
1927–28	64 ,,

* Miles : "Cacao Crop Forecast, 1928-29."

Average for six seasons (*see* Plate II), 79 days, or just over 11 weeks. The annual figures show that the interval between harvesting and shipping is tending to become shorter. This is probably due to the ever-extending road and rail system throughout the Colony and the better organisation of the up-country buying agencies. The shortening of the period may be to some extent counteracted by the provision of better storage accommodation, such as is now being built at some of the ports and up-country.

Effect of Price.

It was expected that the period of lag would show some obvious correlation with changes in price during the year, due to holding up or rushing to the market, but this does not appear to obtain. London f.o.b. prices for Accra cacao have been inserted on the annual graph, and, though changes in values have been considerable, there is no obvious effect on the period of lag.

Monthly Percentages of Total for Year.

Exports.

	1922/23.	1923/24.	1924/25.	1925/26.	1926/27.	1927/28.	Average.
October ...	2.6	2.4	3.1	4.3	5.1	4.2	3.6
November ...	6.7	7.7	11.7	12.7	16.1	11.2	11.0
December ...	11.1	11.0	15.9	17.7	19.8	17.2	15.4
January ...	18.8	17.8	14.3	17.1	12.2	18.8	16.5
February ...	16.3	14.2	15.3	13.5	15.6	17.6	15.4
March ...	12.7	14.4	12.9	11.0	12.6	9.0	12.1
April	6.8	10.2	8.5	7.6	4.7	5.0	7.1
May	6.7	7.5	5.2	2.9	1.5	8.5	5.4
June	4.6	5.8	3.5	4.4	2.4	2.7	3.9
July	7.6	3.1	5.0	4.6	2.7	2.9	4.3
August ...	4.7	2.7	3.6	2.1	3.3	1.6	3.0
September ...	1.2	2.6	1.2	2.3	4.3	1.2	2.1

Production.

	1922/23.	1923/24.	1924/25.	1925/26.	1926/27.	1927/28.	Average.
August ...	1.6	2.5	5.1	1.1	5.6	3.3	3.2
September ...	5.5	12.2	13.1	13.3	12.0	17.0	12.2
October ...	14.3	28.1	18.8	25.0	22.0	22.2	21.7
November ...	37.0	26.8	26.1	19.3	28.0	15.7	25.5
December ...	17.6	11.2	17.9	17.3	17.9	12.0	15.6
January ...	5.2	3.3	9.9	10.6	7.0	11.6	7.9
February ...	3.0	0.3	4.5	1.3	0.6	2.3	1.5
March	1.2	1.5	0.6	1.3	0.5	0.0	0.9
April	3.8	2.1	0.8	0.8	3.6	6.9	3.0
May	7.6	4.6	0.6	5.8	1.9	4.3	4.1
June	2.6	5.3	1.6	3.5	0.9	3.2	2.9
July	0.4	1.9	0.9	1.2	1.7	1.5	1.3

PAPER No. X.

CACAO OBSERVATION PLOTS.

By W. H. BECKETT.

The publication of yield forecasts and of progress reports on the more important crops is a normal function of an agricultural service, and an important one in that it provides an unbiassed estimate.

Schemes for preparing the estimate fall under two broad headings: (1) classification of and deduction from reports of observers throughout the growing districts; and (2) computation from statistics provided by a sampling method.

The wheat crop in England is an example of the former method. Both the Ministry of Agriculture and *The Times* publish estimates prepared from reports of observers. The acreage is known, as a return is rendered by each farmer, and the observers' reports supply yield per acre estimates.

A sampling method is used with success in parts of India with the rice crop. There small patches of paddy are cut throughout each district and computations made of the yield per acre. The area under the crop is estimated.

With cacao in the Gold Coast the acreage is not accurately known, nor the extent of new plantings, nor the area of cacao going out of cultivation. This will necessarily remain so until the bulk of the cacao area has been surveyed on lines described elsewhere in this Year-Book. Hitherto statistics of the yield per acre have only been available from fields on Agricultural Stations, and estimates have relied mainly on observations made by officers travelling through cacao districts.

In order to provide more representative statistics of yield per acre, it was decided to keep accurate records on native farms throughout the cacao areas. No special staff was available, and the observed plots were, therefore, only possible where they were easily accessible by officers carrying out other duties. The attached map shows the distribution of the cacao areas and the points where observation plots have been established.

SELECTION OF THE PLOTS.

The main feature deciding the selection of a plot is its representative character of the district, away from a motor road and surrounded by cacao trees. There is an indication that the increased amount of sunlight reaching roadside trees has a tendency to cause early ripening, and the increased exposure to reduce resistance to insect attack.

Where several plots have been possible at one point, different aged farms have been selected, as this appears to be an important factor in yield. The cacao tree, on reaching maturity, gives increasing yields for a few years and then settles down to a more or less steady reduced yield. In bad seasons the decrease in yield is more noticeable in old than in young farms.

Soil and position are also taken into consideration, so that the plots are distributed over different soil formations and situations, as hill, valley or river-side.

SIZE AND SHAPE.

The plots are about one-tenth of an acre in area and triangular in shape. An equilateral triangle of 100′ sides approximates to this area (.097 acres), is easy to mark out with a 100′ chain, and is not so liable as a square plot to exclude a complete row of cacao, thereby giving an incorrect estimate of the average number of trees per acre.

A sketch map showing the position of each plot is prepared, and the boundaries marked out with stakes or by a line hedge. With the stakes, or hedge plants, spaced at 10′ intervals, it is easy to prepare a spot plan showing the position of each tree. The trees are then numbered by attaching zinc labels to the trunk with a copper tack, or by numbered stakes driven in at the foot of the tree. On the plan cacao trees are represented by the number and shade trees by crosses.

On each plot notes are made of the type of cacao, age of trees, type of soil, situation, drainage, cultivation, shade, etc., so that a card index system may be developed by which plots can be classified and compared.

The trees are classified by girth as follows :—

Under 8″ girth	Small.
8″ to 15″	Medium.
Over 15″	Large.

RECORDING.

The basis of the records taken lies in the fact that the period of development of a cacao pod from the flower to maturity is known. The pods on each tree are counted and classified as follows :—

CACAO OBSERVATION PLOTS.

SURVEY H. Q. ACCRA, 1930.

Length of Pod.	Corresponding Age.
1″ (Small)	1 month from setting.
1″–2½″	1–2 months old.
2½″ and over	2–3 months old.
4½″ and over	4 months old.
Mature (Green) ..	5 months old.
,, (Ripe) ..	6 months old.

The classes are not necessarily exact, as the final size of the mature pod differs with the season, time of the year and the district. It is, however, sufficiently accurate, especially as the mature pods can be measured on reaping.

Each month an observer counts the pods and sends in a return, and where harvesting has been done, a count of the total pods reaped and the number useless for fermenting. When the farmer breaks the cacao pods the net weight is taken. Dry weight will not be generally possible, as the farmer can hardly be expected to ferment the small lots of cacao separately. The percentage of dry to wet weight is, however, fairly constant.

PROGRESS OF SCHEME.

The first plots were established in July, at the beginning of the present major crop season, before any pods were reaped, and, with few exceptions, the records of the current crop are not complete.

The establishment of plots is dependent entirely on the goodwill of the farmer, and although no difficulty has been experienced in obtaining permission to make the monthly counts, it has not been possible in all cases to get figures for the reaped pods and weight of cacao. There is always an inherent suspicion that some ulterior motive is behind the weighing of the produce from a farm, and only as time elapses can schemes such as this be carried out without causing misunderstanding. Another factor also militates against obtaining yield figures on some plots: where the observer is not in continuous contact with the owner it cannot be expected that reaping be done to coincide with the observer's monthly visit. The farmer naturally reaps the cacao from the plot at the time he reaps the rest of the farm. In the few cases where the farmer himself is capable of counting the reaped pods and weighing the cacao his farm is distinctly better than the average, and not a suitable one for our purpose.

The first season is necessarily experimental, in that the main use of the data collected is comparing the current season with previous ones.

A specimen of the collected data from a plot is given below :—

COUNTS OF PODS.

A.B. No. 1.

Date.	Mature.		$4\frac{1}{2}+$	$2\frac{1}{2}+$	1 to $2\frac{1}{2}$	Small.	F.	Total.	Harvested to date.	Grand Total.
	Ripe.	Green.								
August	48	428	87	80	55	24	—	722	—	722
September	311	211	97	45	22	—	—	686	—	686
October	224	93	49	7	—	—	—	373	311	684
November	105	35	—	—	—	—	—	140	535	675
December	13	1	—	—	—	—	—	14	640	654

It is evident from the table that the counts made in August gave a fairly accurate picture of the forthcoming crop. An examination of the different months' records shows that the size-class intervals correspond closely to a month's growth.

When another season's records have been taken it should be possible to obtain an accurate idea of :—

(1) The size of the crop.
(2) The earliness or otherwise.
(3) The distribution over the season,

compared with the previous year.

PAPER No. XI.

FLOWER AND FRUIT PRODUCTION OF THEOBROMA CACAO.

By H. K. HEWISON and N. K. ABABIO.

The preparatory work in connection with a detailed study of fruit production of Theobroma Cacao was commenced during the latter part of May, 1928.

For the purpose ten trees were marked at random from among those of the main stand, and from a definite region of each tree daily records were collected of the following :—

(*a*) Number of flowers opening.
(*b*) Number of flowers shedding.
(*c*) Number of flowers setting fruit.
(*d*) Number of young fruits shrivelling.
(*e*) Number of fruits maturing.
(*f*) Increase in size of maturing fruit.

The trees concerned in this work belong to a stand planted in 1913–14, and are spaced at 13 feet.

The region of each of the ten trees involved in these observations had to be limited to that which could be reached by the worker from ground level. This was found necessary during the period of preliminary trials in May, when attempts at working from an elevated position resulted in such damage to flowers and flower buds as to render the data collected valueless. In all cases, however, the trees fork low, and three or four well-developed branches are within the range of operations, so that the information accumulated does not relate solely to production on the main axis. Particular reference to this will appear later.

The procedure followed involved the insertion of a pin in the bark near a cushion on which a flower opened. On a flower shedding the corresponding pin was removed and the loss recorded. When a fruit set a copper tack, carrying a serial number and the date, was substituted for the pin marking the flower concerned. This serial number, which incidentally gave the location of the fruit on the tree, was entered in the fruit record book.

Before considering the figures of 1928, it must be stressed that the opening date of these records is not the beginning of the flower-

ing period. In all probability flowering was in progress three months before it was possible to commence this study. The fact does not materially detract from the value of the figures, however, so long as it is realised they represent a portion and not the whole.

In 1928 no flowers were observed during November and December, and for the purposes of reviewing the data of that year October 31st is taken as the closing of the flowering period. Adopting such a date is purely a matter of convenience and may not be justified by findings in future years. In the light of present knowledge, however, it is permissible.

Table I summarises the data pertaining to the flowering during the period June to October, 1928.

TABLE I.

Tree Ref.	No. of Flowers opening.	No. of Flowers shed.	No. setting Fruit.	No. of Fruits on Region at Inception of Trial.	No. of Fruits shrivelling.
A	1,874	1,843	31	7	21
B	1,199	1,180	19	3	15
C	778	768	10	3	11
D	1,347	1,327	20	2	16
E	2,354	2,300	54	4	22
F	1,289	1,265	24	1	14
G	535	527	8	0	6
H	433	426	7	3	8
I	1,013	988	25	2	15
J	398	390	8	0	2

With regard to Column 5, "Number of Fruits Shrivelling," under this heading are admitted all fruits which pale off and shrivel from causes presumed at the present stage of our knowledge to originate within the parent tree. In no case is a fruit included in this class when damaged and not reaching maturity through external agency, disease, insect pest or physical injury.

In 1929 records were collected during the entire flowering period. October 31st is again adopted as the close of the flowering period. Evidence to establish that date is still insufficient, but in only one instance did flowers open during that month, and during November and December flowering was sporadic and comparatively negligible.

TABLE II.

SUMMARY OF DATA RELATING TO FLOWERING PERIOD JANUARY 1ST TO OCTOBER 31ST, 1929.

Tree Ref.	No. of Flowers opening.	No. of Flowers shedding.	No. of Flowers setting Fruit.	No. of Fruits shrivelling.
A	5,350	5,302	48	35
B	3,348	3,305	43	18
C	4,669	4,622	47	31
D	5,842	5,809	33	16
E	8,319	8,222	97	46
F	1,605	1,588	17	9
G	1,099	1,088	11	4
H	1,617	1,596	21	6
I	1,952	1,922	30	12
J	1,991	1,973	18	4

The figures of these tables relate only to that region of the tree readily accessible to the observer. What proportion of the total productive area they represent it is extremely difficult to say. The point is not material to this study, as, having obtained some knowledge of the fate of the masses of flowers produced and of the small proportion of fruits that set, our concern is with the causes of the fruit losses that occur and with investigating the existence of factors (other than those genetic in character) which may be responsible for the wide differences that exist between the yields of individual trees.

The suggestion has been put forward that an estimate based on the respective yields of the observed and unobserved regions during the period of record might provide a means of comparison. Even as regards numbers of flowers opening and fruits setting this is doubtful. It certainly can give no safe indication of the relative areas of the trees being studied, nor, as the basis of calculation is but a single crop-year, even of the relative yield values of the region—except, of course, for that year.

For convenience of reference and for the purpose of comparison the data of Columns 3 and 4 of Tables I and II have been expressed in the form of the percentage of flowers which open, and that of the last column as the percentage of fruit shed or shrivelling. These are collected into Table III and a final column added showing the relation between the opening flowers and the fruit that reached maturity.

TABLE III.

Tree Ref.	Flowers shed.		Flower setting Fruit.		Fruit shrivelling.		Mature Fruit as % of Flowers opening.	
	1928.	1929.	1928.	1929.	1928.	1929.	1928.	1929.
A	98.35	99.10	1.65	0.90	55.26	72.92	0.587	0.205
B	98.42	98.72	1.58	1.28	68.18	41.86	0.584	0.507
C	98.72	98.99	1.28	1.01	84.61	65.91	1.257	0.236
D	98.52	99.44	1.48	0.56	72.72	48.48	0.445	0.222
E	97.71	98.83	2.29	1.17	37.93	47.42	1.529	0.529
F	98.14	98.94	1.86	1.06	56.00	52.94	0.853	0.498
G	98.50	99.00	1.50	1.00	75.00	36.36	0.374	0.637
H	98.38	98.70	1.62	1.30	80.00	28.57	0.462	0.928
I	97.53	98.46	2.47	1.54	55.55	40.00	0.987	0.819
J	97.99	99.10	2.01	0.90	25.00	22.22	1.507	0.703

The foregoing tables have all related to the totals of collected observations, in one case for a portion of a year, in the other for a whole year.

With data for a complete flowering period accessible, a review of the efforts of the individuals during that period is rather interesting. Very considerable differences in performance exist among the ten trees of this study, and these differences are not those of quantity alone.

In 1929, following a flowerless period commencing October 12th, 1928, tree "E" came into flower on January 5th, and, with the exception of a break of ten days at the end of March, flowered continuously until October 1st. Tree "G," on the other hand, bore no flowers from August 11th, 1928, until April 2nd, 1929, and after June 18th produced them in mere ones and twos until ceasing altogether on July 23rd.

The distribution of flowering over the year will be considered in greater detail at a later stage in relation to fruit production.

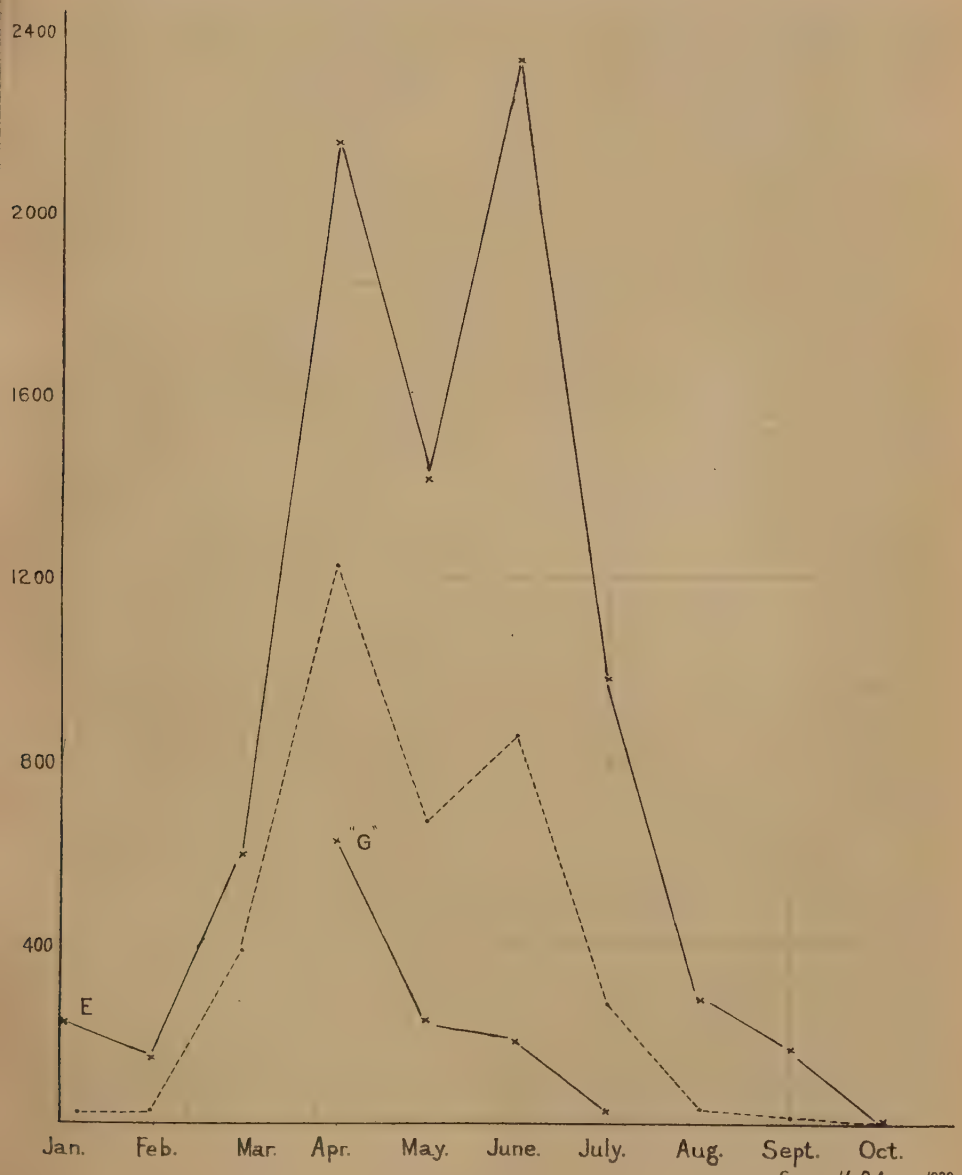
Here it may be noted that in the majority of cases flowering appears to commence in March, assumes considerable proportions during April, and thereafter continues, with varying degrees of intensity, until July. During August flowers are few, and in only three cases do such flowers lead to the formation of fruit. In two of those three instances, however, the fruit which formed amounted to over 13% and 23% of the trees' crop.

On the accompanying graph (Plate I) is plotted the distribution of the flowering of the two most dissimilar trees "E" and "G."

PLATE I

FLOWERING CURVES : TREES "E AND G" (CACAO)

CURVE OF FLOWERING BASED ON AVERAGES OF TEN TREES ------



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"A"

TABLE IV.

MONTHLY DISTRIBUTION OF FLOWERING, SHEDDING AND FRUIT-SETTING ON INDIVIDUAL TREES DURING 1929.

Ceased flowering. 1928.	A. 9/10/28.			B. 4/10/28.			C. 9/10/28.			D. 9/10/28.			E. 11/10/28.			F. 11/10/28.			G. 11/8/28.			H. 16/7/28.			I. 21/9/28.			J. 3/10/28.		
Flower period, 1929.	1/3/29–14/8/29. 167 days.			1/3/29–29/7/29. 151 days.			1/3/29–12/8/29. 165 days.			24/1/29–6/9/29. 225 days.			5/1/29–1/10/29. 269 days.			2/3/29–28/8/29. 179 days.			2/4/29–23/7/29. 112 days.			1/3/29–29/7/29. 148 days.			1/3/29–4/8/29. 157 days.			1/3/29–3/8/29. 156 days.		
	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.	% Flowers.		% Fruit set.
	Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.		Open.	Shed.	
Jan. ..	—	—	—	—	—	—	—	—	—	0.41	0.27	—	2.75	2.59	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Feb. ..	—	—	—	—	—	—	—	—	—	2.74	2.52	—	1.84	1.95	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
March ..	12.49	12.58	2.08	10.63	10.68	6.98	10.64	10.73	2.13	12.41	12.82	6.06	7.14	7.33	—	8.60	8.09	—	—	—	—	17.99	18.11	9.52	18.34	18.52	6.66	15.47	15.52	11.11
April ..	35.83	35.52	70.84	36.41	36.16	55.81	40.50	40.33	57.45	30.14	30.16	27.27	25.87	26.04	11.34	28.22	28.53		57.51	57.63	45.45	43.17	42.98	57.14	30.78	30.78	36.66	45.70	45.82	33.33
May ..	22.84	22.33	4.17	22.91	22.36	4.65	19.62	19.32	4.25	16.80	15.90	12.12	17.15	14.00	9.28	23.43	20.91	23.53	21.19	20.22	18.18	18.18	15.54	4.76	19.88	18.37	6.66	20.44	20.27	5.56
June ..	20.56	19.95	12.50	24.25	24.78	27.91	22.38	22.48	29.79	29.14	29.82	33.33	28.04	30.45	40.21	31.15	32.87	29.41	18.11	18.11	27.27	18.62	21.18	23.82	20.18	21.59	26.68	14.87	15.15	5.56
July ..	7.98	9.17	10.41	5.80	6.02	4.65	6.73	6.92	6.38	7.50	7.42	21.21	11.90	11.92	30.93	7.60	7.55	23.53	3.28	4.04	6.09	2.04	2.19	4.76	4.41	4.06	10.00	3.47	3.14	44.44
Aug. ..	0.30	0.45	—		—	—	0.13	0.22	—	0.72	0.94	—	3.26	3.61	2.06	1.00	1.45	23.53	—	—	—	—	—	—	0.41	0.68	13.33	0.05	0.10	—
Sept. ..	—	—	—	—	—	—	—	—	—	0.05	0.05	—	2.02	1.97	6.18	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Oct. ..	—	—	—	—	—	—	—	—	—	—	—	—	0.02	0.04	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Totals ..	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The curves bring out very clearly the marked difference between the performance of these two trees, both quantitative and in regard to the duration of the flowering period. And, as a further point of comparison, it is interesting to note that in the production of mature fruit from the flowering of 1929, tree " E " has yielded well over seven times as much as " G."

On the same graph is shown by a dotted line a curve of flowering constructed from the monthly averages of the ten trees.

Table IV shows the distribution of flowering, flower-shedding and fruit-setting during the months of the flowering period of 1929.

The figures are percentages of the individual's performance in the three classes, and this form is adopted in order to facilitate comparison.

The actual numbers recorded are already given in Table II.

Of the flowers that opened during the recorded portions of 1928 over 98% were shed, and during the complete season of 1929 shedding accounted for practically 99% of those opening.

To how great an extent this loss is due to non-fertilisation we are not yet in a position to say, and observations on this and the distribution of pollen by natural agencies form the next step in the study under review. That there are factors other than fertilisation operating to occasion shedding seems almost inevitable, although the extent of their influence is a matter of some doubt and has yet to be defined.

Heavy downpours of rain and high winds naturally take a heavy toll of flowers, but such conditions are exceptional and irregular and cannot account for the phenomenon of shedding, which is so essentially regular. As far as general meteorological records are concerned, we have so far failed to associate any feature of temperature or relative humidity, recorded either from instruments within the area of cacao or the general meteorological station outside it, with the shedding of flowers.

One point which may have considerable bearing on the subject and ultimately go far toward indicating the extent to which shedding is attributable to non-fertilisation is the period flowers remain open on the tree and the duration of receptivity of the stigma. Information on the latter question is not yet adequate, but, with regard to flowers remaining open, records show that, whilst the majority are shed on the second and third days, it is by no means uncommon for flowers to remain open five, six or even seven days. This is not peculiar to a particular group of trees nor to any season of the year, although there are indications that it is more common toward the latter end of the flowering period.

With regard to the proportion of flowers setting fruit, it was not possible during the period under review to investigate the problem to the extent it deserves, and little was attempted other than the recording of actual numbers and dates of occurrence Reference to Table III, Columns 4 and 5, shows 2.47% of the total flowers recorded for any one tree to be the highest percentage of setting and 0.56% to be the lowest.

A rather interesting feature in connection with flowering and fruit-setting is suggested by the relevant columns of Table IV. In each of the seven cases where the proportion of fruit set during March and April was greater than 33% of the total setting, the proportion of flowers opening in June was low by comparison with that of April. On the other hand, on the remaining trees, where 33% or less of the crop was set by the end of April, large flushes of flowers appeared in June, the flushes being equal to, or even greater than, those of April. Furthermore, the ratio of setting to flowering during these June flushes was markedly higher than during the previous months.

It would appear reasonable to assume that these June flower-flushes were due to the response on the part of the parent tree to an insufficient consumption of accumulated reserves owing to the small number of developing fruits. The scarcity of fruits is attributable to the poor amount of setting which occurred and not to shedding losses, for in the cases where setting did occur on these trees shedding was at a minimum.

Whether the extremely low proportion of flowers setting fruit is a matter of fertilisation or pollination remains for future investigation.

The peculiar absence of any setting on trees "D," "E" and "F" during the months of their early flowering (in the case of "F" there was no setting even in April, by which time some of the trees had set 60% to 70% of their crop) certainly suggests fertilisation or the absence of pollen-bearing insects.

That the problem of setting is largely bound up in the frequency of pollinating agents seems strongly indicated by our records of the dates on which fruit set. These figures indicate in a most striking manner the occurrence of the great proportion of setting during one short period of each month. The period is usually one of three or four days, and whilst the dates are not the same for all the trees during any one month such is frequently the case for several of them.

During March, 1929, for example, seven trees set fruit, and of that setting over 92% occurred between the 22nd and 25th. In April 60% occurred during the period 21st–24th, nearly 30% being on the 24th.

growth, the selection of the particular day appears permissible, and is in all probability reasonably close to the critical date.

The great proportion of fruits ultimately reaching maturity appear to attain their maximum size in from seventeen to eighteen weeks from fruit setting. That the growth period varies is only to be expected, and measurements show it may be as short as fourteen weeks or as protracted as twenty-two. So far no evidence has been obtained of the association of duration of growth with the season during which growth occurs.

Frequency curve (Plate IV) shows the distribution of pods (ultimately harvested as sound fruit) at the time of attaining maximum dimensions over seven-day periods from fruit setting.

SUMMARY.

(1) The period from March to July is the time of principal flowering activity.

(2) The greatest numbers of flowers are produced during the period April-June.

(3) The number of flowers setting fruit does not exceed 2.5%, and is known to be as low as 0.5%.

(4) Records show that the shedding of flowers is as high as from 97.5 to 99.4% of those opening.

(5) From 0.2% to 1.5% of the opening flowers develop mature fruit.

(6) It has been noted that where less than one-third of a tree's crop is set by the end of April, great flowering activity occurs during June.

During such June flushes the flower-fruit ratio is very much higher than before.

(7) The peculiar tendency for the majority of fruit setting to occur during a brief period each month has been recorded.

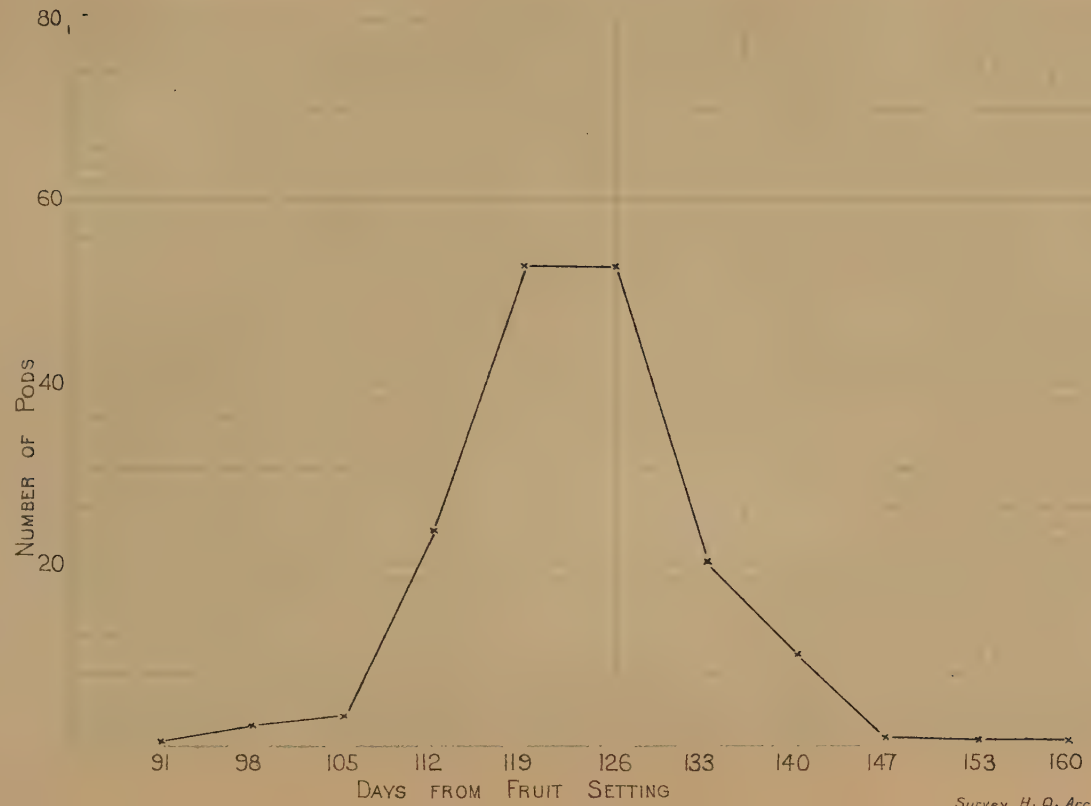
(8) Losses from the shedding and shrivelling of immature pods range from 22% to 84% of the fruit which sets.

(9) Losses of immature fruits are highest during the first week of growth, but from the fourth to the seventh week is also a critical period.

(10) The majority of pods ultimately reaching maturity attain maximum size in seventeen to eighteen weeks.

PLATE 4

CACAO PODS ATTAINING MAXIMUM DEVELOPMENT
DURING
SEVEN DAY PERIODS FROM FRUIT SETTING.



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PAPER No. XII.

A NOTE ON THE DETERIORATION OF CACAO IN THE BISA AREA.

By A. S. THOMAS.

Cacao was first planted in the Bisa area about thirty years ago, and since that time the deterioration of the cacao in this district has been proceeding; for the crop was planted everywhere, in places suitable and in places unsuitable; often it was impossible to establish the trees, in other places they died after a few years.

At first little notice was taken of the failures, as there was plenty of virgin land to be planted, and the areas which came into bearing each year more than compensated for those which died; but within the last few years the position has become alarming, for the supply of new land in the district is almost exhausted and the deterioration has been accelerated by a change in the climate of the region—it has become much drier.

There appears to be two reasons for this change: firstly, the drying action of the *harmattan* has become more intense; and, secondly, there has been a decrease in the annual rainfall. The latter statement is controversial, and is not supported by the rainfall figures from Koforidua—the nearest station with a long series of meteorological records—but Koforidua is on the other side of the Scarp Range and is exposed to the monsoon winds. If there has been no such decrease, it is difficult to account for the apparent lowering of the water table—the rivers when in flood do not attain their former size and some streams no longer appear above ground, not even during the rainy season.

Drought appears to be the primary factor: during the dry season the growth of the cacao is checked, and thus the trees are rendered more susceptible to insect attack. Over the greater parts of the area *Sahlbergella* spp. are the main agents of destruction, attacking all the young shoots as they appear. But on the sandy soils to the south-east of the River Pawmpawm the farmers declare that termites are responsible for the death of old and young cacao, invading the roots first, and working up the stem; that they are primary parasites remain to be proved, but it is certain that in many cases the trees have only been dead for a short time before the trunk is completely tunnelled by the insects, and that some trees fall over owing to the destruction of the tissues near ground level.

The district is hilly, but the general slope of the land is towards the plains to the North and East, and therefore the area is directly exposed to the desiccating *harmattan*. Mr. H. W. Moor, of the Forestry Department, in a paper read before the West African Agricultural Conference,* drew attention to this phenomenon, and pointed out that the effect of the *harmattan* was most evident in the valley of the River Pawmpawm, where in places there has been an intrusion of patches of savannah vegetation. He suggested that as this valley sloped down towards the north-east, the direction of the *harmattan*, it served as a funnel to concentrate the force of the wind and render its drying action the more striking.

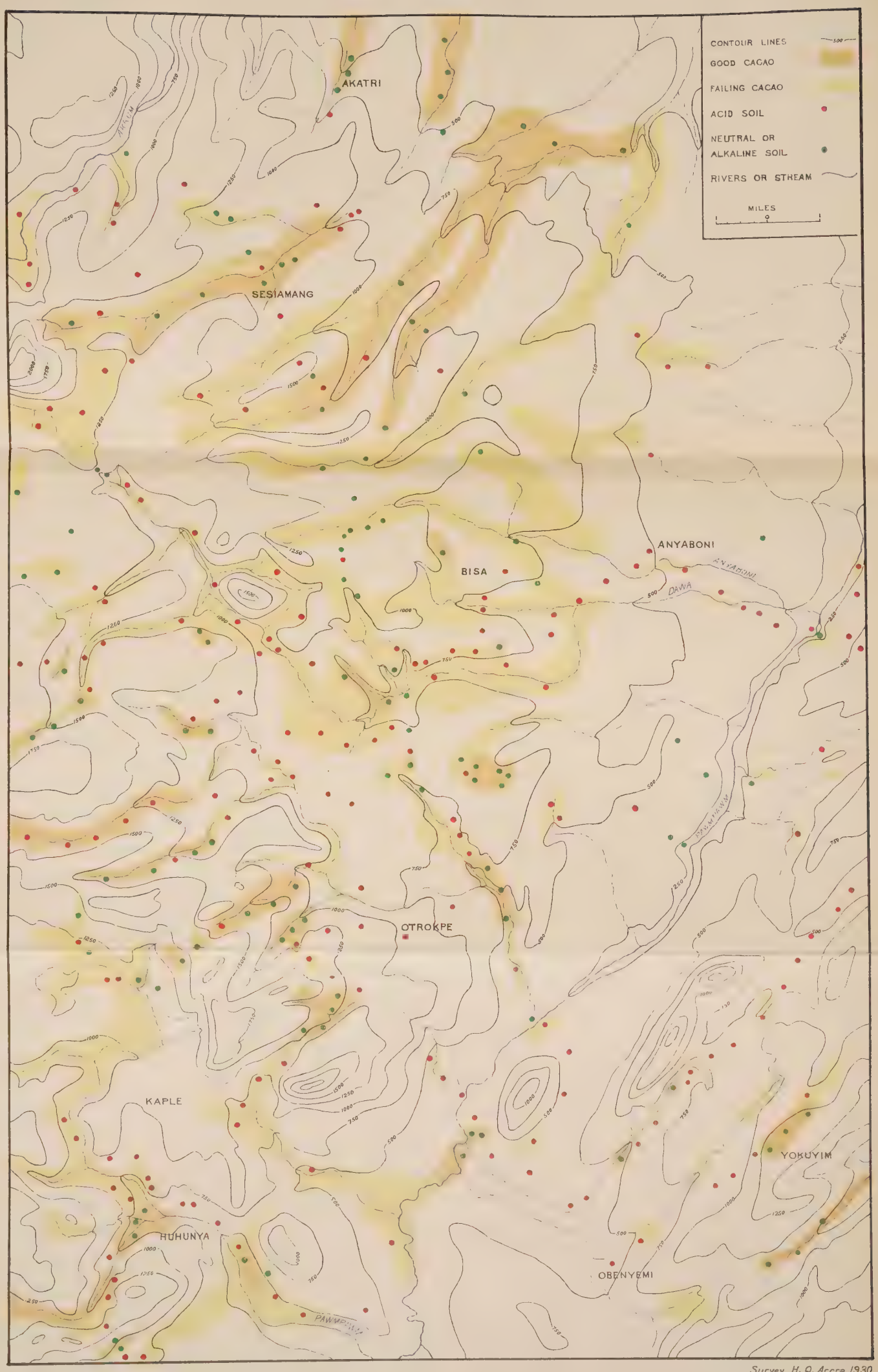
The map of the Bisa district, which accompanies the article, shows roughly the distribution of cacao farms at the present time. The brown tint indicates areas of good cacao, and the yellow tint areas where the cacao is markedly failing; this classification is purely arbitrary, for it is impossible to define exactly the extent or the quality of the cacao plantations. As a rule, where no cacao is shown, it may be assumed that conditions have proved to be unsuitable, for the farmers have attempted to establish cacao on all the cleared land, and there is scarcely any forest left with the exception of some stretches on the tops of the hills in the North.

It may be noticed that most of the cacao is growing in the river valleys, where usually the soil is deeper than on the tops of the hills; but many of the better plantations are in valleys facing to the north-east and directly exposed to the full force of the *harmattan*. At Akatri and Akattui, in the North of the district, the phenomenon is especially striking, for here are large areas of cacao in valleys sloping down to the plains; not only established trees, but also seedlings of all ages are growing within two miles of the open country.

On the map are also shown the results of numerous soil reaction tests made in the field. The technique was crude—a spot was selected as being typical (for the soil often showed considerable local variation in depth, in moisture content and in reaction), a hole 9 inches deep was made with a cutlass and a sample from this depth was tested with B.D.H. universal soil indicator. No comparator was available, so the colours were classified according to an arbitrary scale; on the map these reactions are divided into two groups, those definitely acid (red dots) and those approximately neutral or alkaline (green dots); it is probable that the line of demarcation is in the neighbourhood of *p*H 6.5.

These results, although only approximate, would seem to show that throughout this area there is a marked correlation between good cacao and a neutral or alkaline soil—or, in other words, that the deterioration has been more rapid on the acid soils. Numerous

* Bulletin No. 20, Department of Agriculture, Gold Coast.



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instances may be quoted to show that soil may be of as great importance as is exposure in determining the condition of the cacao : thus at Yokuyim there is a large stretch of good cacao on top of a hill—fully exposed to the *harmattan*, but on a neutral or alkaline soil—while in the sheltered valley below, stretching towards Obenyemi, little good cacao may be seen, and here the soil is mostly acid.

An interesting fact may be noted : that in some places where there has been an intrusion of savannah flora in the valley of the River Pawmpawm the soil resembles that of the plains, being grey in colour, heavier in texture, and less acid than are the red soils of the oil palm plantations in this area. This grey soil appears to be very infertile, cacao cannot be established on it, and oil palms are stunted in growth ; the physical properties of the soil may be the cause—when wet it is a slimy clay, when dry it forms a cement-like mass.

Several exceptional cases were observed in which there was good cacao on acid soils, and failing cacao on alkaline soils. It is not to be expected that samples from a depth of 9 inches should give a complete guide to the soil in relation to a crop like cacao, whose roots were often seen to penetrate to a depth of over 5 feet. Nor is it certain that the actual hydrogen ion concentration is the controlling factor—it may only be an index of certain soil conditions. For instance, alkaline soils in this district are usually heavier than acid ones, and the effect of the physical condition of the soil upon the water supply of the tree may be involved, although it does not appear to be of vital importance ; for in many cases cacao on moist acid soils near the bottoms of valleys is not in so flourishing a state as that on more alkaline soils above. Or the variations in reaction may be an expression of important differences in chemical composition, for, as a rule, the neutral or alkaline soils are grey, brown, black or dark red in colour, as opposed to the light-red tint characteristic of most of the acid soils. Or, again, it is possible that acidity is correlated with a deficiency in available potash, for the " deciduous habit " of the cacao trees here, which is most marked on the acid soils, resembles the symptoms produced by potash starvation in the orchard crops of temperate regions.

Whatever may be the significance of these differences in soil reaction, this district would afford valuable material for a thorough investigation by a soil chemist, and it is probable that without this work, accompanied by entomological, meteorological and botanical observations, a satisfactory explanation of the condition of the cacao farms will not be obtained. Such an investigation would not only be of the utmost value to this district, but it would furnish information of general importance with regard to the suitability of various soils for cacao, information which could serve as a basis for advice in the development of virgin areas and prevent the repetition of a tragedy which is all too common—the destruction of tracts of

forest in the attempt to establish a crop for which a region is unsuited.

SUMMARY.

(1) The deterioration of the cacao in the Bisa area is caused by drought, and especially by the severity of the dry season.

(2) This deterioration is usually more marked in places where the soil is acid than it is in places where the soil is neutral or alkaline.

(3) The problem merits thorough investigation.

PAPER No. XIII.

RESULTS OF CACAO MANURIAL TRIALS.

SUMMARISED BY W. H. BECKETT.

PART I.

A description of the layout of the trials was given by Culham in Paper No. XI in the 1927 Year-Book on the "Initial Variations between Plots used for Cacao Manurial Trials."

The trials were laid out on the Agricultural Stations at Kpeve Kumasi, Asuansi and Aburi.

Kpeve.—The cacao was planted in 1913–14 and spaced 12½′ × 12½′. The plots lie in a sheltered position in hilly country, about 4,000 feet above sea-level. With a deep clay loam soil, and a mean annual rainfall of 52.20 inches, it is one of the highest yielding areas of cacao in the Colony.

Kumasi.—The cacao was planted in 1908–10 and spaced 15′ × 15′. The soil is a medium heavy red loam. The station is adjacent to the town of Kumasi, and in a now generally deforested area. The mean annual rainfall is 58.49 inches.

Asuansi.—The cacao was planted in 1912–15 and spaced 10′ × 10′. The station is about 14 miles from the sea, and thus on the extreme southern edge of the cacao belt. It is, however, inside a belt of forest. The soil is light, overlying a clay subsoil. The mean annual rainfall is 49.59 inches.

Aburi.—The cacao was planted in 1891–93 and spaced 15′ × 15′. The station is on the Aburi Scarp, about 1,500 feet above sea-level. The soil is laterite with gravel. The mean annual rainfall is 47.59 inches.

On all stations the spacing is wider than is commonly met with in native farms, and, with the exception of Kpeve, wider than would now be considered optimum for the respective localities.

TREATMENTS.

The trial at each station consists of eight plots, of roughly a quarter of an acre each. The treatments are as follows :—

1. No mulch	1. No manure.
	2. Dried blood, sulphate of potash.
2. Mulch.	3. Basic slag, sulphate of potash.
	4. Basic slag, sulphate of potash, dried blood.

The quantity of mulch applied varied according to availability of material. At Aburi 3 tons per acre per annum was applied ; at Kumasi and Asuansi 8 tons per annum ; and at Kpeve 24 tons per annum.

The rates of application of the manures in each case were 8 cwts. of basic slag per acre per annum, 2 cwts. of sulphate of potash, and 4 cwts. of dried blood.

The times of application varied on different stations.

The treatments were therefore :—

APPLICATION GIVEN IN CWTS. PER ACRE PER ANNUM.

A.	B.	C.	D.	E.	F.	G.	H.
No Mulch.				Mulch.			
—	D.B. 4	—	D.B. 4	—	D.B. 4	—	D.B. 4
—	S. of P. 2	S. of P. 2	S. of P. 2	—	S. of P. 2	S. of P. 2	S. of P. 2
—	—	B.S. 8	B.S. 8	—	—	B.S. 8	B.S. 8

Areas of Plots.

The following table gives the exact areas of the plots, in acres.

TABLE I.

	A.	B.	C.	D.	E.	F.	G.	H.
Kpeve	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Kumasi	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
Asuansi	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Aburi	0.27	0.31	0.30	0.20	0.25	0.23	0.24	0.26

The differences in area of the plots were unavoidable, as the trial had to be made to fit existing blocks of cacao.

Number of Fruiting Trees.

In the following table is given the number of fruiting trees during each crop-year. Where a tree came into bearing, or was cut out during one year, the number fruiting during the heaviest cropping months was taken.

TABLE II.

NUMBER OF FRUITING TREES.

		Kpeve.	Kumasi.	Asuansi.	Aburi.
1926–27 ..	A	48	36	63	30
	B	62	33	64	42
	C	56	32	76	41
	D	64	33	82	28
	E	55	33	63	32
	F	55	33	55	35
	G	54	31	51	32
	H	48	36	67	39
1927–28 ..	A	48	36	63	30
	B	62	32	64	43
	C	56	32	76	43
	D	64	33	82	28
	E	55	33	63	32
	F	55	33	55	35
	G	54	31	51	32
	H	48	36	67	40
1928–29 ..	A	50	36	63	30
	B	51	33	67	43
	C	56	32	77	43
	D	64	33	79	28
	E	53	33	69	32
	F	55	33	61	35
	G	54	31	64	32
	H	49	36	79	40

Recording.

On each station the ripe pods were picked each month and counts made of the following items :—

1. Number of bearing trees.
2. ,, pods collected.
3. ,, ,, fermented.
4. ,, ,, useless.
5. ,, ,, attacked by insects.
6. ,, ,, ,, fungi.
7. Weight of wet cacao.
8. ,, dry cacao.

Crop Season.

On preparing tables of the total pods collected for all stations it was found that the lowest crop months common to the four stations were March and April, and it was therefore decided to use the April to March year in the analysis of the records. In all tables and in the text the " years " refer to this (12 months) period.

PART II.

CRITERION OF YIELD.

The trial affords an excellent example of the difficulties which present themselves in dealing with an orchard crop.

The yield of one plot may be expressed in terms of the total number of pods produced, in that it gives a measure of the cropping capability. Varying percentages of these pods, however, are unfit for fermenting because the beans have been rendered useless through attack by fungi and insects. The percentage of useless pods, however, depends to a considerable extent on the cropping interval. In this trial the interval is a month, whereas in the native farm it is usually much longer, the farmer cropping his cacao three or four times only during the year. Where, however, the cropping interval is reduced to a week, the loss through disease is lessened, and it is conceivable that if an area was cropped continuously the loss would be reduced to a very low percentage.

If we decide to count only those pods capable of producing cacao, it is still doubtful whether the pod count is a reliable statistic of yield. The farmer is certainly concerned mainly with the weight of the saleable product, but even this is not quite exact, as a few big pods, giving the same weight of dry cacao as a larger number of smaller pods, require less labour and thus give an economically better yield.

Whichever of the three statistics we use, the point remains of the units in which we may conduct the analysis. If on an acreage basis, a plot having a vacancy or two might easily record a lower yield though actually capable of producing more than another plot, if both had a perfect stand. On the other hand, if we choose the tree as a unit, we do not take into consideration the compensating effect of the wider area over which trees, in a plot where vacancies exist, have to feed. Spacing affects yield, and the tree unit basis ignores this effect.

From the considerations outlined above a different unit altogether has been adopted, that is, a unit of "cropping capacity." Lord, in Ceylon, used a method of percentage increase in rubber-tapping experiments, and it is a development of this idea which is used here.

The yield from a plot is expressed as a percentage of the total yield of the block in which it is situated, the blocks consisting of four plots having different manurial treatments. The complete blocks may, or may not, have received mulch. In measuring the effect of mulching, the block yields are expressed as percentages of the total yield for the two blocks (comprising the eight plots) (*see* Table IIIB).

The effect of the treatments is measured by computing the difference between the percentages of the first and the two succeeding seasons separately.

PART III.

YIELD FIGURES AND ANALYSIS.

Total Pods Collected.

Table III shows the actual number of pods collected during the three years. Each figure represents the sum of twelve monthly records.

In Table III (*a*), these yields are expressed as percentages of block totals (*e.g.*, Plot A at Kpeve in 1926–27, 5441 is 28.4% of 19,156.

TABLE III.

TOTAL PODS COLLECTED.

		Kpeve.	Kumasi.	Asuansi.	Aburi.	Totals.
1926–27	A	5,441	1,813	1,383	2,447	11,084
	B	5,067	1,710	1,783	3,252	11,812
	C	3,967	642	1,925	2,717	9,251
	D	4,681	843	1,044	2,588	9,156
		19,156	5,008	6,135	11,004	41,303
	E	3,702	1,924	1,321	3,411	10,358
	F	4,039	863	1,443	3,177	9,522
	G	4,092	2,002	2,052	3,474	11,620
	H	3,161	1,871	1,273	3,584	9,889
		14,994	6,660	6,089	13,646	41,389
		34,150	11,668	12,224	24,650	82,692
1927–28	A	3,400	1,156	1,725	1,926	8,257
	B	3,527	875	2,424	4,723	11,547
	C	3,208	1,172	2,515	4,135	11,030
	D	4,238	1,728	1,816	2,752	10,534
		14,373	4,931	8,480	13,586	41,370
	E	1,857	1,752	1,888	3,581	9,088
	F	2,438	1,117	2,086	3,169	8,810
	G	3,849	2,489	2,758	3,428	12,524
	H	2,715	2,144	3,020	4,029	11,908
		10,859	7,502	9,752	14,217	42,330
		25,232	12,433	18,232	27,803	83,700

TABLE III—*continued.*

		Kpeve.	Kumasi.	Asuansi.	Aburi.	Totals.
1928–29	A	5,295	994	1,534	1,758	9,581
	B	5,427	838	2,220	3,765	12,250
	C	4,241	1,172	2,117	3,437	10,967
	D	5,589	1,551	1,690	1,975	10,805
		20,552	4,555	7,561	10,935	43,603
	E	3,488	1,917	1,477	2,714	9,596
	F	4,538	1,050	1,891	3,238	10,717
	G	4,110	1,790	2,856	3,775	12,531
	H	3,987	2,168	2,872	3,534	12,661
		16,123	6,925	9,196	13,261	45,505
		36,675	11,480	16,757	24,196	89,108

TABLE III (*a*).

PODS COLLECTED EXPRESSED AS PERCENTAGE OF BLOCK YIELDS.

		Kpeve.	Kumasi.	Asuansi.	Aburi.	Totals.
1926–27	A	28.4	36.2	22.5	22.2	109.3
	B	26.4	34.2	29.1	29.6	119.3
	C	20.8	12.8	31.4	24.7	89.7
	D	24.4	16.8	17.0	23.5	81.7
	E	24.7	28.9	21.7	25.0	100.3
	F	26.9	13.0	23.7	23.3	86.9
	G	27.3	30.0	33.7	25.4	116.4
	H	21.1	28.1	20.9	26.3	96.4
1927–28	A	23.6	23.4	20.3	14.6	81.9
	B	24.5	17.7	28.6	34.8	105.6
	C	22.4	23.9	29.7	30.4	106.4
	D	29.5	35.0	21.4	20.2	106.1
	E	17.1	23.4	19.4	25.2	85.1
	F	22.5	14.9	21.4	22.3	81.1
	G	35.4	33.1	28.3	24.2	121.0
	H	25.0	28.6	30.9	28.3	112.8
1928–29	A	25.8	21.8	20.3	16.1	84.0
	B	26.4	18.4	29.4	34.5	108.7
	C	20.6	25.7	28.0	31.4	105.7
	D	27.2	34.1	22.3	18.0	101.6
	E	21.6	27.7	16.1	20.5	85.9
	F	28.2	15.2	20.6	24.4	88.4
	G	25.5	25.8	31.1	28.5	110.9
	H	24.7	31.3	32.2	26.6	114.8

TABLE III (*b*).

Mulching Percentages.

	Kpeve.		Kumasi.		Asuansi.		Aburi.		Mean.
	No Mulch.	Mulch.	No Mulch.	Mulch.	No Mulch.	Mulch.	No Mulch.	Mulch.	
1926–27	56.0	44.0	42.9	57.1	50.2	49.8	44.7	55.3	48.45 51.55
1927–28	56.9	43.1	39.7	60.3	46.5	53.5	48.9	51 1	48.00 52.00
928–29	56.0	44.0	39.7	60.3	45.2	54.8	45.2	54.8	46.53 53.48

These percentages, which are now our yield statistics in "units of cropping capacity," cut out the effect of differences due to locality, size of plot and number of trees per acre. Considered as these "units," rather than "percentages," it is legitimate to sum them and take means. Below they are grouped according to treatments.

For the manurial treatments the totals are arrived at by summing the yields of plots receiving the same application of artificial manures on all four stations. Thus 104.8 is the sum of the A plots and E plots on all stations, divided by two, as in this respect they are replications. The only difference between the A and E is in application of mulch.

TABLE IV (*a*).

Manured.

Expressed as Average Percentage of Block Totals.

Manures.	Treatments.			
	1	2	3	4
1926–27	104.8	103.1	103.05	89.05
1927–28	83.5	93.35	113.7	109.45
1928–29	84.95	98.55	108.3	108.20
Differences.				
1st and 2nd year ..	−21.3	−9.75	+10.65	+20.40
1st and 3rd year ..	−19.85	−4.55	+5.25	+19.15
Mean	−20.58	−7.15	+7.95	+19.78

Mulching.

In Table III (*b*) the first entry, 56%, is calculated from 19,156 and 34,150. From this table the means are grouped below.

TABLE IV (*b*).

	No Mulch.	Mulch.
1926–27	48.45	51.55
1927–28	48.00	52.00
1928–29	46.53	53.48
Differences.		
1st and 2nd year ..	−0.45	+0.45
1st and 3rd year ..	−1.92	+1.92
Mean	−1.29	+1.29

These differences are discussed in Part IV.

Useless Pods.

The effect of manurial treatments on incidence of disease has been recorded in different crops. To measure the effect here the number of useless pods recorded for each plot was expressed as a percentage of the total pods collected on that plot. These figures were then grouped, and averaged for stations, manurial treatments and mulching in a way similar to that used for total pods collected.

TABLE V.

USELESS PODS EXPRESSED AS PERCENTAGE OF TOTAL COLLECTED

	Kpeve.	Kumasi.	Asuansi.	Aburi.	Means.
1926–27 ..	6.38	7.59	3.39	5.89	5.81
1927–28 ..	10.52	13.51	7.41	5.55	9.25
1928–29 ..	9.97	16.70	10.89	8.49	11.51

Manures.	Treatments.			
	1	2	3	4
1926–27	5.97	6.93	5.18	5.17
1927–28	8.94	9.77	9.90	8.37
1928–29	10.73	12.04	11.71	11.57
Differences	2.94	2.84	4.72	3.20
	4.76	5.11	6.53	6.40
Mean	3.85	3.98	5.62	4.80

TABLE V—*continued.*

Mulching.	No Mulch.	Mulch.
1926–27	5.44	6.19
1927–28	8.08	10.42
1928–29	7.15	15.87
Differences	2.64 1.71	4.23 9.68
Mean	2.48	6.96

Number of Pods per lb. of Dry Cacao.

An increase in yield may be due to a larger weight of cacao per pod. To measure any such effect the number of pods fermented from each plot (in complete years) was divided by the dry weight pounds, and a table prepared of number of pods per lb. per plot each year. These figures were then grouped and averaged as for useless pods.

TABLE VI.

NUMBER OF PODS PER LB.

Stations.	Kpeve.	Kumasi.	Asuansi.	Aburi.	Means.
1926–27 ..	12.8	11.4	10.6	13.3	12.0
1927–28 ..	12.4	11.2	12.5	15.0	12.8
1928–29 ..	13.5	11.8	11.1	14.2	12.6
Mean ..	12.9	11.5	11.4	14.2	12.5

	Treatments. (Manures).			
	1	2	3	4
1926–27	12.28	12.3	12.0	12.0
1927–28	13.0	12.7	12.9	12.8
1928–29	12.8	12.4	12.6	12.7

(Mulching.)

	No. Mulch.	Mulch.
1926–27	12.1	12.1
1927–28	12.9	12.8
1928–29	12.5	12.8

Dry Weight per Acre.

The total dry weight from each plot for each year was expressed in lbs. per acre, and the figures grouped and averaged in Table VII below.

TABLE VII.

DRY WEIGHT PER ACRE.

Stations.	Kpeve.	Kumasi.	Asuansi.	Aburi.	Means.
1926–27 ..	1,277	718	556	864	854
1927–28 ..	880	709	670	830	773
1928–29 ..	1,241	592	669	761	816
Mean ..	1,133	673	632	818	814

Manures.	Treatments.			
	1	2	3	4
1926–27	872	897	849	797
1927–28	670	727	828	865
1928–29	689	831	854	889
Mean	744	818	844	850

Mulch.	No Mulch.	Mulch.
1926–27	828	879
1927–28	756	789
1928–29	829	803
Mean	804	827

Dry Weight per Tree.

From the dry weights recorded and number of fruiting trees the dry weight per tree per annum for each plot was calculated and the figures grouped in Table VIII

TABLE VIII.

Dry Weight per Tree in lbs.

Stations.	Kpeve.	Kumasi.	Asuansi.	Aburi.
1926–27	5.55	3.58	2.14	6.21
1927–28	3.98	3.54	2.87	6.04
1928–29	5.74	2.95	2.39	5.52
Mean	5.09	3.36	2.47	5.92

Treatments.	1	2	3	4
1926–27	4.45	4.27	4.31	3.64
1927–28	3.44	3.70	4.15	3.89
1928–29	3.52	4.30	4.18	4.00
Mean	3.80	4.09	4.21	3.84

Mulching.	No Mulch.	Mulch.
1926–27	4.00	4.34
1927–28	3.65	3.97
1928–29	4.07	3.94
Mean	3.91	4.08

PART IV.

DISCUSSION OF RESULTS.

Before discussing the results in detail, a note on the general method of analysis adopted is necessary. In these trials the manurial treatments are duplicated on each station, one series having a mulching trial superimposed. The stations are widely separated, and it is not considered legitimate to treat the blocks on the four stations as four replications. It is for this reason that percentages have been used. Furthermore, the trials are designed to give indications of the lines along which replicated experiments of manurial treatments should be planned. Indications of the effect can be got from the foregoing analysis, and no statistical analysis to determine the order of the error is considered either valid or advisable

In Table IV (*a*) it is seen that the no-manure plots have declined in total pod production, relative to the mean, by 20.58%. The effect of all treatments is set out below :—

1. No manure .. .. .. —20.58%.
2. Dried blood s. of p. .. .. —7.15%.
3. S. of p. basic slag.. .. .. +7.95%.
4. D. b., s. of p., and basic slag .. +19.78%.

There is evidence of the response generally to the application of manure, and chiefly of the application of basic slag. This confirms ideas which have been held by agriculturists in the Colony for some years. The major component in fruit production is phosphate, and in our acid soils the application of lime in the slag enables the tree to make fuller use of the mineral food in the soil.

The difference in the percentages of the mulched and unmulched plots is not large enough to prove any definite effect.

In Table V the fluctuations in the percentages of useless pods are large, and, except in the case of mulching, cannot be said to be significant. It would appear, however, that heavy mulching has a tendency to increase the percentage of useless pods.

In Table VI the number of pods per lb. of dry cacao appears to depend much more on station and season than on the treatments given. It can be inferred that the increase in the crop due to the treatments is in the increased number of pods and not in the size of pod.

In Table VII the dry weight per acre yields show similar tendencies to the total pod counts. The differences in the percentage of useless pods is not sufficient to mask the effect of the treatments.

In Table VIII the chief interest lies in the order of the stations. By comparing Tables VII and VIII it will be seen that the order of yield is changed.

Dry weight per acre. lbs.	Kpeve	.. 1,133
	Aburi ..	.. 818
	Kumasi	.. 673
	Asuansi	.. 632
Dry weight per tree. lbs.	Aburi ..	.. 5.92
	Kpeve	.. 5.09
	Kumasi	.. 3.36
	Asuansi	.. 2.47

The abnormally high yield at Kpeve is obtained by a high yield per tree, with a higher number of trees per acre than at Aburi. The difference between the yields is not marked between Kumasi and

Asuansi in dry weight per acre, but very marked in dry weight per tree. The compensating factor is the higher number of trees per acre at Asuansi.

The seasonal fluctuations differ widely on different stations: 1927–28 is the lowest year at Kpeve, but the highest for the other three stations.

In conclusion, it should be remembered that only the broadest inferences can be drawn from the above analysis. It is most likely that there is a differential effect due to the season and due to the locality, and rigid trials are necessary in the different localities, over different seasons, to decide individual points.

The broad inference, however, may be drawn that basic slag had a beneficial effect in increasing the yield of cacao.

PAPER No. XIV.

REPORT ON THE OCCURRENCE OF SAHLBERGELLA SPP. AND OTHER INSECT PESTS OF CACAO IN FERNANDO PÓO, SAN THOMÉ AND THE BELGIAN CONGO.

By G. S. COTTERELL.

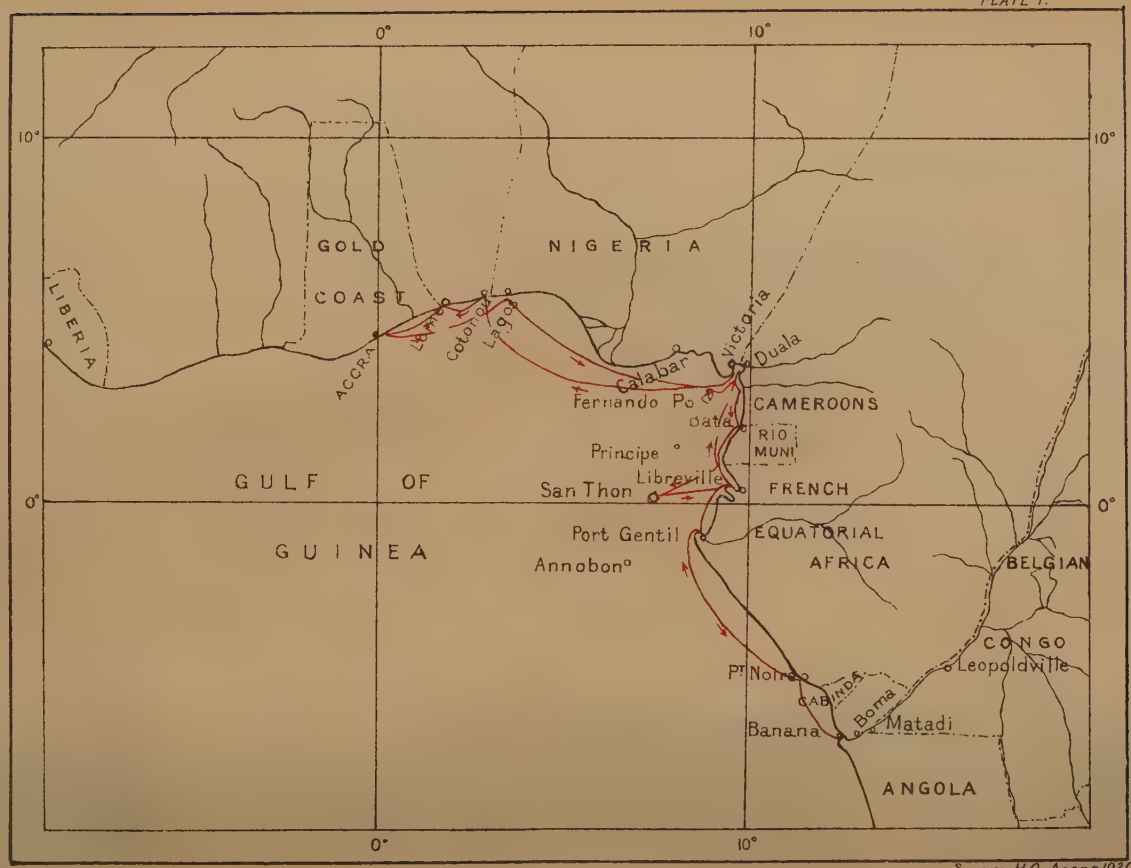
INTRODUCTION.

In Bulletin No. 3 of the Department of Agriculture, "Preliminary Study of the Life-history and Habits of *Sahlbergella singularis*, Hagl., and *Sahlbergella theobroma*, Dist.," reference is made to the possibility of one or both of these species of Capsid bug, which are serious pests of cacao on the Gold Coast, having been introduced from San Thomé or Fernando Póo. Again, in the Proceedings of the First West African Agricultural Conference, 1927, the writer submitted a paper entitled "Pests of Cacao in the Gold Coast," in which reference is again made to the possibility of introduction. As a result of this paper a resolution was passed suggesting that an Entomologist be sent to Fernando Póo and San Thomé to study the possibility of the occurrence of *Sahlbergella* spp. in these two Islands, from which they had not hitherto been recorded, with a view to finding natural enemies non-existent in the Gold Coast and the introduction of same as a control. A visit to the Belgian Congo was added, as it was thought that study in another cacao-producing country on the mainland of West Africa, where *Sahlbergella* was known to be a pest, would be of value. It was not expected that natural enemies differing from those that occur here would be found in the Congo.

The present paper is a report on a visit made to these three countries in the latter part of 1928 and January, 1929. Part II refers to the occurrence of *Sahlbergella* spp. in each country and Parts III and IV to the occurrence of other pests.

The writer's thanks are due to the Governments of the three countries visited for facilities granted, and also to the various plantation-managers and staff encountered, from whom much useful information was obtained. The writer's thanks are also due to the British Museum authorities for the names of some of the insects collected.

PLATE I.



Survey H.Q. Accra 1930

PART I.

DESCRIPTION OF COUNTRIES VISITED.

FERNANDO PÓO AND SAN THOMÉ.

The Islands of Fernando Póo, under Spanish, and San Thomé, under Portuguese, administration, are situated in the Gulf of Guinea, off the West Coast of Africa, the former in latitude 3.5 N. and longitude 8 W., and the latter in latitude O. and longitude 6.40 W. The equator cuts through the south of the latter.

Fernando Póo is considerably larger than San Thomé, comprising an area of 760 square miles, whereas San Thomé is only 386 square miles. Both are of volcanic origin, but Fernando Póo is obviously a very much newer formation geologically. This has a considerable effect on the nature of the soils encountered in each Island. Both are exceedingly mountainous, Fernando Póo rising to a single peak, 10,000 feet high, cultivation being confined to the slopes below 2,000 feet. San Thomé rises to a number of peaks, the highest being the Pico de San Thomé, a little over 6,000 feet in height. The slopes are considerably steeper than those encountered in Fernando Póo, and cultivation is chiefly confined to the many sheltered ravines that occur. Both Islands are plentifully supplied with water, there being a large number of perennial streams.

Climate.

The climate of the two Islands is somewhat different, as is shown by the records of rainfall (*see* Appendix). In Fernando Póo no official rainfall records have been taken, but a few privately owned plantations have taken records since 1923. It will be seen that the dry season is similar to that of the Gold Coast, but not so marked. December, January and February are comparatively dry, whereas the remainder of the year is wet, reaching a maximum rainfall in August and September, after which the rains gradually tail off. The *harmattan* is never strong, and the temperature is moderate throughout the year, ranging from a minimum of 65 deg. F. to a maximum of 95 deg. F., the hottest period being in February and March and the coolest during the rains. During the rains the sky is generally overcast, there being very little sun.

In San Thomé, on the other hand, the seasons are reversed. The months of July, August and September are comparatively dry, whereas the remainder of the year is wet. There is no *harmattan.* The coolest part of the year is during the dry season, when the sky is usually overcast, and the hottest during the rains. The prevailing wind is from the South, and has a considerable effect on the rainfall in different parts of the Island. Whereas in the North the rainfall is only approximately 30 inches (considerably less actually on the coast), in the South it averages 250 to 300 inches, although the Island is only 30 miles long.

Soils.

The soils of the two countries are very different. The parent rock in both cases is basalt. In the case of Fernando Póo it is difficult to say how much of the soil is derived from decomposed basalt and how much from volcanic matter deposited, as distinct from lava. (The presence of lava is unquestionably deleterious to the cultivation of crops.) In Fernando Póo the soil on the slopes of the mountain is generally of great depth, varying from 15 to 60 feet and of exceedingly heavy texture. In San Thomé many different types are encountered, varying from shallow to heavy textured soils of considerable depth. Gravelly and argillaceous soils are common.

Cultivation of Cacao.

Only approximately one-sixth of the Island of Fernando Póo is cultivated, cacao being practically the only crop. A certain amount of cacao is now being replaced by coffee. The export of dried cacao amounted to 8,439 tons in 1927. Practically all available land is cultivated in San Thomé, cacao again being the major crop. Exports of cacao from the two islands during the last fifteen years are given in the following table :—

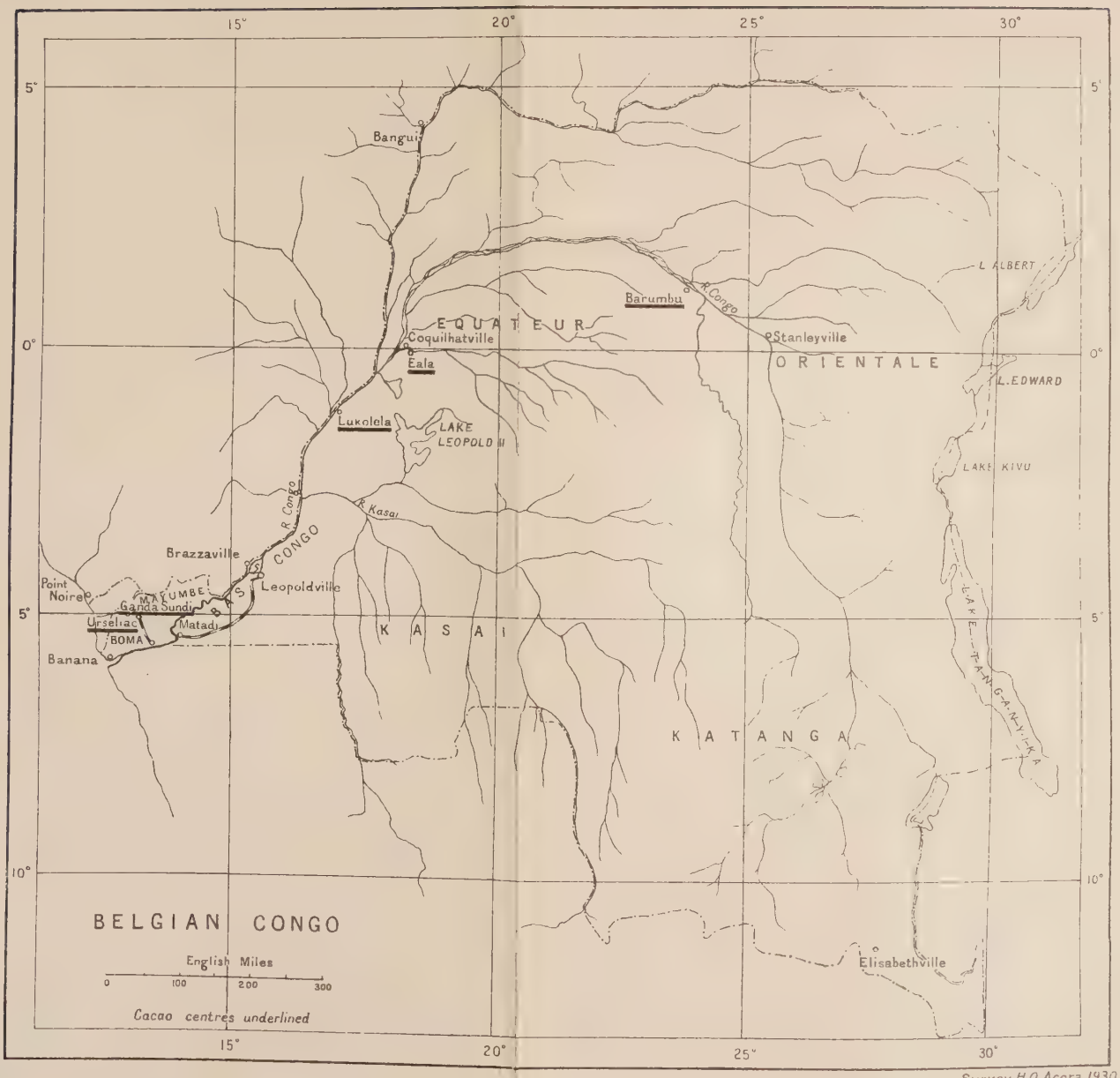
Annual Export of Dried Cacao from Fernando Póo and San Thomé.

Year.	Fernando Póo.	San Thomé.*
1913	4,332 metric tons	36,311 metric tons
1914	3,114 ,, ,,	31,400 ,, ,,
1915	4,159 ,, ,,	29,500 ,, ,,
1916	4,405 ,, ,,	34,178 ,, ,,
1917	3,744 ,, ,,	31,882 ,, ,,
1918	4,464 ,, ,,	18,332 ,, ,,
1919	4,640 ,, ,,	49,945 ,, ,,
1920	5,050 ,, ,,	21,471 ,, ,,
1921	6,702 ,, ,,	28,276 ,, ,,
1922	10,090 ,, ,,	18,577 ,, ,,
1923	8,641 ,, ,,	12,786 ,, ,,
1924	6,021 ,, ,,	24,934 ,, ,,
1925	6,905 ,, ,,	18,482 ,, ,,
1926	6,756 ,, ,,	13,881 ,, ,,
1927	8,439 ,, ,,	14,000 ,, ,,

Cacao seasons in Fernando Póo are approximately the same as those in the Gold Coast, except that the main season is considerably earlier. In San Thomé there is no definite season, cacao being reaped

* Records obtained from "Gordian," "Tropical Life" and Knapp's "Cocoa and Chocolate."

PLATE 2



Survey H.Q. Accra, 1930.

practically the whole year round. The heaviest crops are obtained from April to July, and from October to the end of December.

Cacao in both countries is almost entirely grown on European plantation lines. In Fernando Póo a large number of plantations originally established by the local natives have been acquired by Europeans in the last few years. Cacao was first established in San Thomé in 1822. Plantations in the latter island are a model of organisation. Each represents a small township of its own, having its own buildings for European staff and African labour, and its own port and railways.

The variety grown in both countries is Forastero. In Fernando Póo certain plantations are experimenting in budding Criollo on to Forastero stocks.

BELGIAN CONGO.

Conditions in the Belgian Congo are entirely different to those in either Fernando Póo or San Thomé. The Congo is a vast country extending from latitude 13.5 S. to 5 N. and longitude 12.2 W. to 31.4 W. Altitudes vary from sea-level to 6,000 feet. Climatic conditions are therefore extremely varied in different parts. The cultivation of cacao is confined to the equatorial region alongside the Congo River, and to the Mayumbe district of the Bas-Congo in latitude 5 S. The cultivation of cacao may therefore be divided into two regions climatically, these being the Equatorial Province in the higher Congo and the Mayumbe district in the Bas-Congo.

Climate.

Climatic conditions in these two areas differ considerably, as can be seen in the attached rainfall records. Whereas in the equatorial region there is no marked dry season, in the Mayumbe there is a dry season of five months' duration, lasting from May to September, when comparatively low temperatures are encountered. There is no *harmatten* season. During the dry season in the Mayumbe the sun is rarely seen. A high degree of daily humidity pertains and thick morning mists are the general rule. The humidity increases as the season advances. It is for this reason that cacao can exist over so long a period without rain.

The equatorial region is flat and covered with secondary forest, except in isolated areas, the oil-palm being the commonest tree. The soil is mostly of lateritic origin and frequently alluvial. This region consists of a basin which was originally occupied by a huge inland sea. Soils in this region are, as a general rule, of poor quality and shallow.

The Mayumbe is mountainous, altitudes from 1,500 to 3,000 feet being common. It is of volcanic origin. The soil is derived from limonite, mica-schists and sandstone, and is of heavy texture

and frequently of considerable depth. A characteristic is a layer of conglomerate at a varying distance from the surface. The thickness of this layer and distance from the surface naturally has an effect on the quality of the soil. Gravelly soils are also common. Alluvial soils are found in the valleys bordering the many perennial streams. Parts of this region are covered with dense primary forest, with occasional areas of open country. Otherwise the vegetation is in the transitional stage between wet and dry conditions. Cacao is grown on the alluvial soils and on soils of heavy texture where there is sufficient depth. Shade is apparently unnecessary to cacao except when growing on the poorer alluvial soils. With deep soils of heavy texture, otherwise soils with a high water retentive power, lengthy periods between rainfall are not an important factor. Larger yields are obtained from unshaded than shaded cacao when grown on heavy textured soils. The forest is necessary for the general preservation of humidity, but is being rapidly removed owing to the large clearings that are being made for the cultivation of the oil-palm, the major agricultural industry of the district. The cultivation of cacao is merely a side-line.

The following table is given showing the monthly production of dried cacao at Ganda-Sundi in the Mayumbe. The table indicates the reason why, given no lengthy period of exceptionally low humidity, yield is benefited by the absence of shade. It will be noticed that there are two distinct seasons of comparatively equal size: one from April to July and the other from October to December inclusive. The former ripens when there is very little sun, and therefore light is needed if a reasonable crop is to be formed.

YIELDS OF DRIED CACAO IN POUNDS, GANDA-SUNDI (MAYUMBE)

Month.	1921.	1922.	1923.	1924.	1925.	1926.	1927.	1928.
January .	—	1,432	2,644	573	990	8,074	6,611	11,385
February .	—	—	—	—	990	2,200	—	—
March .	—	—	—	—	385	5,731	6,780	—
April .	3,080	2,200	—	4,136	—	1,100	27,165	15,400
May .	5,500	12,100	16,500	26,400	33,360	41,481	50,661	45,540
June .	7,700	3,300	26,400	45,375	51,700	59,950	82,104	37,180
July .	3,729	1,873	13,200	13,200	26,484	15,147	23,588	28,600
August .	—	—	15,400	12,376	8,800	15,862	19,690	42,240
September	—	—	6,600	12,100	14,905	8,690	12,280	26,400
October .	5,500	9,036	4,400	22,000	15,246	20,845	43,747	36,800
November	16,500	13,817	9,680	22,000	55,000	32,109	38,883	44,000
December	7,700	19,888	11,880	13,117	107,305	26,004	62,986	59,400
	49,709	63,646	106,704	171,277	315,165	237,193	374,495	346,945

Note.—Planted in 1916–17. An additional acreage planted in 1920 is included in 1925 records and onwards, five years being allowed for trees to come into bearing. Records from 1921 to 1924 inclusive are yields from 11,000 acres, and 1925 to 1928, 12,800 acres.

The export of dried cacao is decreasing every year. In 1927 only 837 tons were exported, 565 tons coming from the Mayumbe (of which 262 tons were produced by one company) and 272 tons from the higher Congo.

PART II.

THE OCCURRENCE OF SAHLBERGELLA SPP.

FERNANDO PÓO.

Sahlbergella singularis occurs on cacao in all parts of the Island, and is particularly common on cacao over twenty-five years of age, chiefly on account of the occurrence of "Die-back" on trees growing in exhausted soil, followed by flushes of new growth. These flushes do not occur on younger trees except when growing in obviously poor soils. At the time of the writer's visit the cacao season had commenced, and a large number of nymphs were found congregating under pods. Nymphs of the earlier instars were commonest, indicating that an efficient control exists in the nymphal stages. No new parasites were obtained, but the Braconid parasite, *Euphorus sahlbergellæ*, was found to be far more abundant than on the Gold Coast. Parasitism on the Gold Coast varies from 1% to 3%, whereas in Fernando Póo, at the time of the writer's visit, 12% was obtained. This is partly due to the greater degree of humidity, dry conditions being unfavourable to the development of the parasite, a feature that is marked on the Gold Coast, as is shown by the following table :—

PERCENTAGE PARASITISM OF *Sahlbergella singularis* AT ASAMANKESE, GOLD COAST, BY *Euphorus sahlbergellæ* IN RELATION TO RAINFALL.

Month.	No. of *S. singularis* Nymphs collected.	No. of parasitic Pupæ obtained.	Percentage of Nymphs parasitised.	Monthly Rainfall in Inches.	No. of rainy Days per Month.
May, 1926 ...	135	7	5.2	5.89	14
June, 1926 ...	97	7	7.2	9.27	19
July, 1926 ...	99	1	1.0	3.40	13
August, 1926 ...	131	0	0.0	1.44	9
September, 1926 ...	275	21	8.0	5.88	18
July, 1927 ...	1,503	57	3.7	6.44	9
August, 1927 ...	12,324	332	2.6	1.11	5
September, 1927 ...	14,027	458	3.2	4.28	11
October, 1927 ...	11,099	298	2.6	6.60	13
November, 1927 ...	13,458	311	2.3	4.37	9
December, 1927 ...	5,159	72	1.3	7.61	11
January, 1928 ...	8,800	63	0.71	0.13	1

In the Gold Coast there is a large increase in the *Sahlbergella* population during the ripening period. Leaving out of consideration the mid-season crop, from which only a small percentage of the total crop is obtained, the majority of cacao is harvested in the months of October, November and December (1). At this period, although a heavier monthly rainfall may occur than in the main wet season, *i.e.*, May, June and July, the number of rainy days is less and the amount of sunshine is considerably more (2), resulting in large variations in the daily humidity. In Fernando Póo the majority of cacao ripens and is harvested well before the finish of the rains. The rains reach their maximum in August and September, and during this period sunshine is infrequent. It is during these months that the majority of pods are harvested and when *Sahlbergella* reaches its maximum concentration.

Increased parasitism is, however, chiefly due to the absence of the hyperparasite, *Mesochorus melanothorax*, of the Gold Coast. From fifty odd parasitic cocoons obtained during the writer's stay in Fernando Póo not a single adult of this Ichneumonid was bred out, whereas in the Gold Coast hyperparasitism is as high as 42%.

Attack by *S. singularis* is therefore not so severe as on the Gold Coast, although it is considered a pest of major importance by the majority of European planters. Attack is sporadic as on the Gold Coast, but damage never reaches the same dimensions. The trees are better able to withstand attack as the water-retaining power of the soil under unfavourable conditions is better than the average Gold Coast soil. On the Gold Coast " Die-back " invariably adds to the damage caused by *Sahlbergella* attack, as the soil is opened up to the sun, lowering the humidity in the actual plantation.

Sahlbergella theobroma was not observed, although a large amount of young cacao in a favourable condition for attack was searched. Neither was any damage observed that could be credited to this species. On one plantation, consisting of 1,200 acres of young cacao of all ages up to four years, and therefore all favourable to attack by *S. theobroma* if existent, no sign of attack was observed after an exhaustive search. It was therefore concluded that this species was not present in the island, as it would have been attracted to such an extensive area of food-plant. Further search is necessary, however, before a definite statement can be made.*

Up to the present time only two species of *Sahlbergella* are known to the British Museum (Natural History), these being the two species that occur in the Gold Coast. In the course of breeding out parasites from *S. singularis* nymphs, adult species of a closely allied genus of *Sahlbergella* were obtained. The nymphs had been

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* *S. theobroma* has not been recorded as occurring outside the Gold Coast. In the Cameroons, before the war, the Germans did a considerable amount of work on the pests of cacao, but there is no record of the occurrence of *S. theobroma*.

collected in company with *S. singularis* nymphs on cacao, no difference being noticed in the nymphal stage.*

The alternative breeding plants of *Sahlbergella* spp., *Eriodendron anfractuosum*, and *Bombax* spp. are abundant in Fernando Póo. No new food-plant was discovered.

No control measures are generally carried out. However, on one European-owned plantation, decisive results in lessening attack have been obtained by the use of manures. This plantation consists of a number of scattered blocks that were originally native farms and which were taken over four years ago. At the time of their acquisition the cacao on these blocks was suffering considerably from the attack of *Sahlbergella*. Artificial manures, consisting of nitrogen, potash and phosphate, in varying percentages, were systematically applied as soon as they were taken over. After four years *Sahlbergella* is doing very little damage to these trees, although adjacent farms are being seriously attacked. What attack there is, is chiefly confined to the leaf-petioles, indicating adult attack only, no oviposition taking place. The owner informed the writer that he had obtained the best results from manures containing a high percentage of Potash.

SAN THOMÉ

During the writer's stay in San Thomé, owing to the facilities given by the Portuguese Government and by plantation administrators, most of the plantations in the Island were visited. No sign of the occurrence of either species of *Sahlbergella* was observed, although a most extensive search was made. It was therefore presumed that they do not exist in the Island, although their alternative food-plants are common.

San Thomé apparently enjoys immunity from these pests, so important on the mainland, owing to its isolation. Conditions are ideal for the spread of *Sahlbergella* on account of the frequent leaf-fall subsequent to attack by *Heliothrips rubrocinctus*, and therefore frequent production of new wood. The Government of San Thomé should prevent the introduction of *Sahlbergella* spp. at all costs.

This immunity does not apply only to *Sahlbergella* spp. Other pests of the mainland, such as *Characoma stictograpta*, are also absent, whereas pests such as *Heliothrips rubrocinctus* are of greater importance than on the mainland owing to the absence of natural enemies.

BELGIAN CONGO.

Sahlbergella singularis is found in practically every plantation in the Belgian Congo and is a serious pest. Owing to the distances

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* This species has since been described by Mr. W. E. China as *Bryocoropsis Cotterelli* sp.n. (Bulletin Entomological Research, Vol. XX, Part 3, p. 253).

between cacao plantations in the higher Congo, amounting in some cases to as much as 500 miles, it is obvious that *Sahlbergella* is indigenous to the mainland. It could hardly have been introduced on pods to each plantation individually when the latter were originally commenced. Neither could it have spread in the few years that cacao has been established in the higher Congo considering the distances to be covered. *Sahlbergella theobroma* was not observed and has never been reported from the Belgian Congo.

In the higher Congo the experience has been that cacao has done well for the first few years and then been attacked, indicating that *S. singularis* is the only species responsible. Regrettably, the writer was unable to meet any of the specialist officers of the Department of Agriculture. Dr. Staineur, State Mycologist, has stated in one of his reports that he found a species of *Sahlbergella* on *Eriodendron* suckers, and it is possible that this may have been *S. theobroma*. *S. singularis* has not been observed to attack *Eriodendron* suckers in the Gold Coast.

As stated earlier in this paper, the soils of the higher Congo are mediocre. In addition, the forest is mostly secondary in nature. The effect of changes in humidity are, therefore, much more marked than would be the case with cacao growing in rain forest or on a heavy soil. There are constant flushes of new growth, followed by considerable *Sahlbergella* damage. In a number of areas the cultivation of cacao has been abandoned on account of repeated attacks and poor yields.

In the lower Congo, in the district known as the Mayumbe, *S. singularis* is again a pest of considerable importance. Here soil and humidity conditions are vastly superior to those that occur in the higher Congo. The soil is of heavy texture, and there are areas in which primary forest still exists. In these areas, where sufficient depth of soil occurs, cacao is doing well irrespective of attack by *Sahlbergella*. In other areas, where the forest has gone and where heavy textured soils occur, but of little depth, damage by *Sahlbergella* is considerable. In the majority of places in the Mayumbe cacao is planted on alluvial soil, where in the past it has done extremely well. However, on this type of soil, shade is much more necessary than on a heavy textured soil.

On one plantation, where cacao is planted on alluvial soil and where overhead shade is present, the yield has fallen from a total of nearly 300 tons in 1918 to 60 or 70 tons in 1928. The manager attributes this almost entirely to *Sahlbergella*. This plantation was commenced in 1898 and came into bearing in 1903. The older trees are always more liable to attack, but trees of no more than fifteen or seventeen years of age have also been completely wiped out, these being some of the best-yielding trees on the plantation. In examining the rainfall statistics of this plantation over the last twenty-five years it will be seen that the rainfall is now only one-third of what

it was in 1904–5, and also that 1918 and 1919 were exceptionally dry years. The year 1919 is looked upon as the crisis in the development of cacao in the Mayumbe. Numbers of plantations on alluvial soil lost so many trees that they gave up the cultivation of cacao. The drop in rainfall and periodic dry years are obviously due to the extensive clearing that has been going on during the last ten years for the establishment of large oil-palm plantations.

In this area the oil-palm will not produce fruit unless opened up as much as possible to the sun.

Owing to the indiscriminate destruction of forest going on in the Gold Coast there is every likelihood of the same thing happening given two consecutive years of exceptionally low rainfall. In fact it has already occurred in the case of cacao growing on poor soil. In addition, there is *S. theobroma*, which is a serious limiting factor in the development of new cacao.

One plantation in the Mayumbe, also on alluvial soil, had been severely attacked by *Sahlbergella*, as was indicated by old cankers on the branches. Artificial manure (superphosphate) has been applied and has been applied regularly during the last few years, resulting in cessation of attack.

Although not confirmed by the writer, *Sahlbergella* is stated by some cultivators to be more common on cacao growing under evergreen forest conditions, particularly when forest trees are left for shade. Attacks are said to originate in the neighbourhood of *Eriodendron* trees. In some cases these trees have been cut down with apparently good results. However, the writer did not observe a single case of *Eriodendron* being attacked by *Sahlbergella* or of attack being localised to areas in the neighbourhood of *Eriodendron*.

No artificial means of control by means of spraying are carried out. Owing to the low value of cacao and the high cost of production on plantation lines, spraying is not an economic proposition. In the Mayumbe the cultivation of cacao is gradually being abandoned in favour of the oil-palm.

The Braconid parasite, *Euphorus sahlbergellæ*, is present in the Belgian Congo, but is comparatively rare. No new parasites were observed. A Reduviid predator, *Carcinomma astrologus*, was reported by Ghésquère (3) in 1922 as being predaceous on *Sahlbergella*. It is described as having a close resemblance to *Sahlbergella* in coloration and appearance. This predator was not observed by the writer. There are numerous casual predators that attack *Sahlbergella* in the Gold Coast.

CONCLUSIONS.

1 Conditions under which cacao is grown differ considerably in Fernando Póo, San Thomé and the higher and lower Congo.

2. As a result, the comparative occurrence of *Sahlbergella* is very different in all the places visited.
3. Neither species of *Sahlbergella* occurs in San Thomé, nor was any damage that might be attributed to these species observed.
4. Cacao in San Thomé is exceedingly favourable to the development and spread of *Sahlbergella* spp. if they existed, owing to the continuous flushes of new growth following repeated attacks by *Heliothrips rubrocinctus*. San Thomé owes its immunity to its isolation from the mainland.
5. *Sahlbergella theobroma* was not observed to occur in either Fernando Póo or the Belgian Congo, nor was any damage observed that might be attributed to this species.
6. *Sahlbergella singularis* is almost as common in Fernando Póo as in the Gold Coast. Owing, however, to the absence of the hyperparasite, *Mesochorus melanothorax*, parasitism by *Euphorus sahlbergellæ* is considerably higher.
7. Owing to the widely separated cacao areas in the Belgian Congo, and the general occurrence of *Sahlbergella singularis*, it is obvious that this species has not been imported but is indigenous to the mainland.
8. In Fernando Póo *Sahlbergella singularis* is more serious on trees over twenty-five years of age and on trees that have been replanted on land which has previously been occupied by cacao, indicating that soil exhaustion plays an important part in bringing about the conditions favourable to attack.
9. In the Belgian Congo cacao growing on alluvial soils is more liable to damage from *Sahlbergella* attack than that growing on heavy textured soils.
10. The absence or presence of overhead shade has no effect on the *Sahlbergella* population except indirectly, when the soil is unsuitable for the growth of cacao over long periods of drought or excessive rainfall.
11. In both Fernando Póo and the Belgian Congo *Sahlbergella* attraction and attack has been lessened by the systematic application of manures.

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PART III.

MINOR PESTS OF CACAO IN FERNANDO PÓO, SAN THOMÉ AND THE BELGIAN CONGO.

The majority of the minor pests of cacao which occur in the Gold Coast are also found in Fernando Póo, San Thomé and the Belgian Congo. Some are of greater or lesser importance, depending on the conditions under which cacao is grown in the respective countries. There are also a few additional pests that have not been recorded from the Gold Coast.

PESTS ATTACKING FOLIAGE.

Two species of weevil, identified as *Ischnotrachelus theobromæ* sp.n.* and *Myllocerus* sp. ign., are comparatively common on unshaded cacao in Fernando Póo. Damage by similar weevils has been observed in the Gold Coast on moribund cacao. Damage is caused by the adults, and is confined only to foliage exposed to the sun and wind.

Menius parvulus. Jac.

The adults of this Eumolpid beetle attack the leaves as well as pods, but the damage is insignificant. This beetle is common in the Mayumbe district of the Congo on cacao growing without shade. Attack consists of small perforations in the leaves.

Zonocerus variegatus. L.

This Acridiid, which attacks a large variety of plants, was observed to be common on young cacao grown without shade. It was not observed as a pest in either San Thomé or Fernando Póo, and is only a pest of young cacao in the Gold Coast when there is inadequate shade and poor soil.

Parasa spp.

The larvæ of Limacodid moths of this genus are stated to be common defoliators in the Belgian Congo on cacao grown without overhead shade. They were not common at the time of the writer's visit, but probably become so during the dry season. No damage by these larvæ was observed either in Fernando Póo or San Thomé. No Limacodid has been recorded as damaging cacao on the Gold Coast.

Diacrisia spp.

The larvæ of these Arctiid moths have been reported by Mayné (1) as attacking cacao-foliage in the Belgian Congo. On the Gold Coast *Diacrisia* spp. have only been observed attacking moribund cacao grown without shade. Their attacks are confined to the succulent foliage put out after heavy *Sahlbergella* attack or "Die-back."

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* Described by Dr. G. A. K. Marshall, C.M.G. (Bulletin Entomological Research, Vol. XX, part 2, p. 201.)

In the Gold Coast defoliating-insects are uncommon except for occasional outbreaks. All those mentioned above are only found on cacao growing under unsuitable conditions, especially where exposure is excessive. In the Belgian Congo, particularly in the Mayumbe district, cacao has been grown almost entirely without shade, climatic conditions being apparently suitable for cultivation on these lines. As a result, these insects are pests of more importance than they would be under shade conditions.

ATTACKING PODS.

Characoma stictograpta. Harp. (The Moth Borer of Cacao Pods.)

Reference is made to the habits of this pest in the 1927 Year-Book of the Department (2). Damage is done by the larvæ, which bore into the pericarp of developing pods but do not damage the seeds. The damage caused is liable to result in subsequent fungus infection. This pest is common in Fernando Póo and the Belgian Congo. It has not been reported from San Thomé and was not observed by the writer. The absence of this pest in the latter country is no doubt due to it not being indigenous. Damage was found to be more prevalent in Fernando Póo than in the Gold Coast on account of the greater degree of humidity. The prevalence of "Brown Pod" disease, *Phytophthora faberi*, is partly due to the prevalence of this pest. In Fernando Póo a number of planters spray with Bordeaux Mixture as a control for pod-disease. In some cases Paris Green is added, resulting in a subsequent lessening in attack. In the equatorial region of the Congo attack is exceedingly common. It is possible that another moth borer, namely, *Anomis leona*, Schaus., is partly responsible for damage in this locality, as the general appearance of damage is different and borings have been observed to enter the mucilage of the pod. Unfortunately the writer spent insufficient time in each place to breed out adult specimens. *Anomis leona* occasionally attacks pods on the Gold Coast.

The few cases of pod-disease seen in the Belgian Congo were mostly associated with pod-borer attack.

Euproctis mediasquamosa. Baker.

The larvæ of this Lymantriid moth occasionally attack the pericarp of pods as well as the foliage. Damage was only observed in the Belgian Congo. The larvæ have been observed attacking moribund cacao on the Gold Coast. Attack is an indicator of bad conditions for cacao, such as excessive exposure and poor soil conditions.

SUCKING-INSECTS.

Helopeltis spp.

Both nymphs and adults are common on cacao in Fernando Póo, particularly on cacao with little shade. Damage was observed

Plate 3.

PROCTIS MEDIASQUAMOSA,
—Adult (after Mayné)

Fig. 1.

CHARACOMA STICTOGRAPTA,
Hamp.—Adult.

Fig. 3.

PROCTIS MEDIASQUAMOSA,
Larva (after Mayné)

Fig. 2.

CHARACOMA STICTOGRAPTA,
Larva (after Mayné)

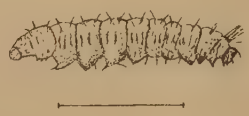

Fig. 4.

CAMENTA OBESA,
Burm.—Adult.

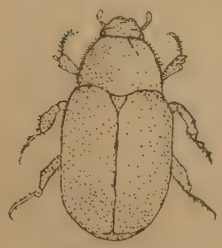

Fig. 5.

CAMENTA OBESA,
Larva.

Fig. 6.

Survey H.Q. Accra, 193

only on pods. The amount of attack does not appear to be affected to any appreciable extent by manuring, as is found to be the case with *Sahlbergella*.

Damage is uncommon in San Thomé, but is common in the equatorial region of the Belgian Congo, where cacao is grown as a general rule with overhead shade. In the Mayumbe district of the lower Congo damage is comparatively uncommon, even on unshaded cacao. The reason for its abundance in the equatorial region is unknown, but it is probably the result of some soil condition.

Toxoptera spp.

An Aphid, similar in habits to *Toxoptera aurantii*, the Cacao Aphis of the Gold Coast, is common in San Thomé and the Mayumbe district of the Congo on herbaceous shoots. This is quoted as being *T. coffea* in the Congo and as *T. coffea* var. *thomensis* by De Seabre (3) in San Thomé. As it is usually found on shoots that normally should be pruned, damage by this pest may be considered as negligible.

Mesohomotoma udamostigma tessmanni. Aulm.

This Psyllid is common in the Mayumbe district of the Congo and also attacks herbaceous shoots. A heavy infestation was seen on a large plantation entirely devoid of shade. This pest was exceedingly uncommon in San Thomé and Fernando Póo at the time of the writer's visit.

Atelocera serrata. West.

According to Mayné (1), *Atelocera* is common on plantations in the Belgian Congo. The adults suck the branches and developing pods, causing cankers. The nymphs have been observed to attack the young branches only. This bug occurs on the Gold Coast, but damage by it is negligible. In the latter country both nymphs and adults have been observed sucking pods, causing malformations, the extent of which depends on the stage of development of the pod. This bug was not observed in San Thomé or Fernando Póo.

Heliothrips rubrocinctus. Giard.

The occurrence of *H. rubrocinctus* in San Thomé, in which country it is a pest of major importance, is referred to in Part IV of this paper.

In Fernando Póo and the Belgian Congo Thrips is of no more importance than it is in the Gold Coast. In the Mayumbe district of the latter it is uncommon even on unshaded cacao growing on mediocre soils. The internal parasite, *Dasyscapus parvipennis*, Gahan, of the Gold Coast, has been observed by the writer to occur in the Congo. In Fernando Póo a number of trees are infested with nests of a small predaceous ant, *Rhoptromyrmex* spp. Thrips are rarely found on trees infested with this ant.

Stictococcus spp.

The scale, *Stictococcus* spp., is uncommon in all three countries with the exception of Fernando Póo. In the latter country it was observed attacking leaf-petioles, attended by a species of black ant. It is uncommon to see it in this situation in the Gold Coast.

Aspidiotus tribolitiformis.

This scale is common in all three countries, but damage is insignificant.

ROOT-FEEDING PESTS.

In Fernando Póo the larvæ and adults of the Rutellid, *Camenta obesa*, Burm., are a serious pest of young cacao. The larvæ and adults are found in the top 6 inches of soil feeding on the taproot and lateral roots, the latter being cut off within a few inches of their origin. Attack also occurs on older trees, but is not so serious on account of the stronger root system. Attack on young trees invariably results in their death. Attack is characterised by drying up of the foliage and subsequent abscission as distinct from that of root diseases where the leaves wilt but are not cut off. The appearance of attack is similar to that of Thrips or " Die-back." A similar beetle is known to attack the roots of cacao in the Cameroons, where a similar soil occurs. The beetles obviously find the thick loamy soil characteristic of Fernando Póo to their liking. From around the roots of a three-year-old tree the writer collected as many as forty adults and larvæ.

A few planters fumigate the soil around the base of an attacked tree, with usually good results, a German proprietary insecticide being used. Other planters have gone in for extensive manuring, with apparently good results. In a country such as Fernando Póo, where a high price for cacao pertains, the general use of manures and insecticides is an economic proposition.

Heterodera radicola.

In San Thomé and the Belgian Congo difficulty is encountered in establishing new cacao on land that has previously been under cacao for some years, the plants making very little growth even three or four years after transplanting. It has been stated by a number of planters, and also by scientific authorities in the Belgian Congo, that the cause of this is the Nematode, *Heterodera radicola*, which attacks the lateral root-system. The writer examined a number of young cacao trees for Nematode nodules on the roots whilst in the Congo. Nodules containing Nematodes were found, but not in sufficient quantity to account for the slow growth being made. A similar condition occurs on the Gold Coast with cacao growing on sterile soils. In the writer's opinion, this slowness of growth is due to soil exhaustion rather than to any pathological cause. Nematodes may be a contributory factor. Authorities in

Plate 4.

EULOPHONOTUS MYRMELEON,
Feld. Adult (after Mayné)

Fig. 1.

EULOPHONOTUS MYRMELEON,
Adult (after Mayné)

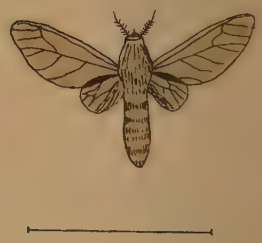

Fig. 2.

EULOPHONOTUS MYRMELEON,
Larva (after Mayné)

Fig. 3.

TRAGOCEPHALA ANSELLI,
Bates Larva (after Mayné)

Fig. 4.

TRAGOCEPHALA ANSELLI,
Adult (after Mayné)

Fig. 5.

DIACRISIA MACULOSA,
Cam. Adult (after Mayné)

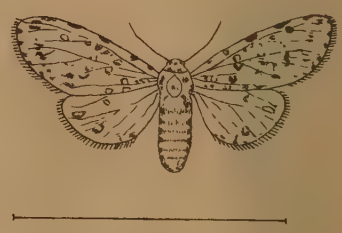

Fig. 6.

the Congo have stated that this Nematode is one of the most important limiting factors in the development of cacao in that country.

Heterodera is found on a large number of weeds and grasses, where it appears to do little harm. It is commonly found on *Ageratum* sp.

Nematodes are occasionally found on the roots of cacao in this country, but are not a pest.

BORERS.

Stem and twig borers are considerably more important in San Thomé and the Belgian Congo than they are on the Gold Coast. They are particularly abundant in the Mayumbe district of the Congo on account of the large amount of extraneous shoots produced by unshaded cacao.

Tragocephala spp.

Species of this longicorn are the commonest borer in the Belgian Congo. None were observed in San Thomé. Old damage, probably caused by *Tragocephala*, was observed in Fernando Póo. The two species recorded from the Congo are *T. anselli*. Bates, the most abundant, and *T. maynei*. Gahan. Those recorded from the Gold Coast are *T. gorilla*. Thomp. and *T. chloris*. Chev.

In the Congo *T. anselli* and *T. maynei*, similar to *T. gorilla* on the Gold Coast, attack branches up to 2 inches in diameter.

An attacked branch is characterised by a line of frass holes on one side of the attacked stem, the size of which depends on the age of the larva. These holes are covered with exudations of frass and gum.

In the Gold Coast *T. chloris* and *T. gorilla* have been bred from young cacao ; the latter from older cacao also. The adult beetle makes a number of incisions near the growing point of a shoot, completely girdling it. An egg is then oviposited a short distance above the ring. The resulting larvæ bore downwards, pupating near the base of the shoot. The appearance of the frass holes is similar to those of *T. gorilla* in older branches. In the Congo similar damage is done by another longicorn borer not yet determined. The writer observed a large amount of damage caused by this beetle in the Mayumbe district of the Congo, but was unable to breed out specimens in the short time available. Mayné (2) states that extensive damage is done by the larvæ of this longicorn, but does not say whether adult specimens were bred out. The majority of damage appears to be done by the adults, the shoot being girdled without oviposition necessarily taking place. Attack is confined to herbaceous shoots. Prevalence of this pest is due to the abundance of herbaceous shoots that are produced by unshaded cacao. Attack is much more common on unshaded and weedy plantations.

The larva of another species of borer of much larger size was also found to be common in the Congo. This is probably *Moecha adusta*. Har., which has been previously recorded as attacking cacao in that country. The larvæ bore in the larger branches and trunks of older cacao.

Eulophonotus myrmeleon. Feld.

This moth borer is common in San Thomé and the Mayumbe district of the Congo. The larva bores into similar wood as *Tragocephala* spp., but borings are easily distinguished from the latter by the absence of the rows of frass holes.

Eulophonotus was at one time reported as common on the Gold Coast, but now is rarely seen. In the Congo it is heavily parasitised by an unidentified Tachinid.

Apate monachus. L.

The adult beetle bores into the main stems of older trees. Only one case of damage was seen by the writer, and that in the Congo on a tree that was unhealthy. In the Gold Coast attack by *Apate* is limited to trees in a moribund condition.

Other Borers.

The adults of an unidentified Scolytid, probably *Xyloborus* sp., are frequently seen boring into the main stems as soon as a tree commences to show symptoms of attack by what is known in the Belgian Congo and San Thomé as "Mort Subite." This is a physiological disease which results in the death of all the lateral roots. A stage is reached when the balance of supply between root and leaf breaks down and the tree immediately commences to wilt. It is at this stage that adults are attracted in number. In no case have these beetles been observed attacking a healthy cacao tree.

The weevil, *Alcides* sp., has been observed attacking the growing shoots of older cacao in the Belgian Congo. Damage by *Alcides* has been observed in the Gold Coast, but is rare.

De Seabre (4) quotes three other species of borer as attacking cacao in San Thomé, these being *Macratoma edulis*, Karsch., *Ancylonotus tribulus*, F., and *Sternotomis rufozonatus*. A species of the latter has been recorded as attacking cacao in the Gold Coast, but is rare.

Termites.

Termite attack is exceedingly common in San Thomé, chiefly on account of the amount of dead and moribund wood left as a result of Thrips attack. Two species were found to be common, these being probably *Schedorhinotermes putorius* and *Neotermes gestroi*, quoted by De Seabre (5) as being the most important. In the writer's opinion, it is doubtful if they are attracted to anything

more than dead or moribund wood, but they will certainly attack healthy wood to get to moribund wood.

Only one case of termites attacking live healthy wood has been observed in the Gold Coast. In this case the roots of young trees were completely eaten away in a period of a few hours.

Schedorhinotermes putorius has been reported by Patterson (6) as attacking *Ficus* sp. on the Gold Coast subsequent to severe borer injury, but has not been recorded as attacking cacao.

Other species of termites quoted by De Seabre are *Neotermes pallidicollis*. Sjöst., *Microtermes parvus theobromæ*. Desn., and *Termes ostentans*.

ATTACKING STORED CACAO.

Insect enemies of stored cacao in all three countries are unimportant on account of the effective methods of preparation and storage. Insect enemies of stored cacao are entirely the result of defective methods. The weevil, *Araecerus fasciculatus*, is occasionally a minor pest in Fernando Póo in beans stored over from one season to another. There is a preferential tariff on cacao entering Spain, but until recently only for a limited number of tons. Cacao produced in excess of this tonnage is, as a general rule, held over until the following season. It is this cacao that is occasionally attacked.

SUMMARY.

1. From the above notes it will be seen that, with certain exceptions, such as Thrips in San Thomé, insect attack appears to be much more severe in the Belgian Congo than elsewhere.
2. This is due to the conditions under which cacao is growing. Cacao in Fernando Póo, San Thomé and the Gold Coast has been established under ideal conditions. The same conditions do not apply to the Congo. The presence of these minor pests indicates that, with certain exceptions, the majority of areas now under cacao in the Congo are unsuitable for this crop.
3. The majority of minor pests listed are uncommon on the Gold Coast and are found attacking cacao growing under unfavourable conditions, such as poor soil and excessive exposure, where cacao is in a weak state of health.

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PART IV.

NOTES ON THE OCCURRENCE OF HELIOTHRIPS RUBROCINCTUS, GIARD, IN SAN THOMÉ, AND POSSIBILITY OF CONTROL BY BIOLOGICAL MEANS.

During the last thirteen years *Heliothrips* (*Selenothrips*) *rubrocinctus*, Giard, the Red-banded Thrips of Cacao, has done considerable damage to cacao in the Islands of San Thomé and Principe, resulting in enormous loss of yield and the death of a large number of trees. This insect, which is a minor pest in almost all cacao-growing countries in the world, was first described by Giard in 1901. The first record of its occurrence as a pest in San Thomé was made by De Seabre (1) in 1916, but it may have been existent in the Island for some years before (2). It has been known in the Gold Coast since 1912 (3). It was recorded from the West Indies some years (1898) before this, as well as from most other cacao-growing countries.

Annual exports have fallen from an average of 32,164 metric tons for the period 1913 to 1917 inclusive to 16,817 metric tons for the period 1923 to 1927 inclusive. This drop is almost entirely attributed to the attack of *H. rubrocinctus*. On some plantations a drop of over 66% has occurred over a similar period.

In 1923 Mr. Patterson (4), then Entomologist of the Gold Coast Department of Agriculture, visited San Thomé with the object of studying the conditions of its occurrence there, as it was considered possible that this pest, which is an important minor pest in this country, but nowhere near as important as has previously been thought, would increase to the same extent following the indiscriminate destruction of forest and lack of cultivation that was then occurring. The San Thomé planters exercise a high standard of cultivation that is never seen on the mainland under native land ownership. Therefore, except for the possible effect of an island climate as distinct from that of the mainland, it cannot be said that the increase of Thrips is due to faulty cultural methods, otherwise a similar condition of affairs would be happening on the mainland. The only conclusion that can be arrived at, in the writer's opinion, is that this pest has recently been imported without its natural

enemies. This theory is supported by the fact that prior to 1916 Thrips was not recognised as a pest.

It has been stated that the chief reasons for Thrips having become a pest of such importance are due to the prolonged dry season and the destruction of overhead shade and protective wind-breaks. This is undoubtedly partly the case, but Thrips is as serious a pest in the south of the Island, where a prolonged dry season does not occur, as in the north, and severe infestations are not necessarily confined to slopes facing the sea. It appears, therefore, that dry conditions, the effect of drying winds blowing in from the sea, and the absence of shade, cannot be the only factors responsible for damage reaching such enormous proportions. Similar conditions, as far as exposure to drying winds are concerned, occur in Fernando Póo and on the banks of the Congo River in the Belgian Congo, in neither of which localities is Thrips a serious pest. A similar lengthy dry season, with a high degree of humidity, occurs in the Mayumbe district of the lower Congo, and in this district Thrips is also not a pest. Attack is undoubtedly due to a number of conditions disadvantageous to the growth of cacao, these being (i.) age of trees; (ii.) washing out of humus from the soil on the steeper slopes (cacao is grown on slopes as steep as 1 in 1); (iii.) absence of adequate protection from drying winds blowing in from the sea; (iv.) exhaustion of soil following continuous production of cacao on the same land. They are not sufficient, however, to account for the extraordinary degree of infestation that occurs.

It is significant that a number of cacao pests that occur on the mainland are missing, notably *Sahlbergella* spp. and the Pod Borer, *Characoma stictograpta*. It appears probable that *H. rubrocinctus* is a comparatively recent introduction. *H. rubrocinctus* has a number of alternative food-plants, including a number of ornamental plants. A number of the latter have been introduced into San Thomé in recent years, and it is possible that the pest was introduced on one of these. This theory is supported by the absence of specialised natural enemies and the severity of infestation on other alternative food-plants such as the Avocado (*Persea gratissima*), and on *Terminalia* spp., as compared with attack on these trees on the mainland.

There appears to be only one predator of any importance whatever as far as the checking of Thrips is concerned, this being the larva of an unidentified Chrysopid. This predator is stated to be more effective in the south of the Island than in the north. A few larvæ feeding on Thrips colonies were observed by the writer, but in such small numbers proportionately to be insignificant. De Seabre (5) quotes the Coccinellid, *Exochomus flavipes*, as being a check, but this insect is uncommon. Spiders predaceous on Thrips and entomogenous fungi are also checks to a small extent, as they are in the Gold Coast.

In the Gold Coast *H. rubrocinctus* is attacked by the Eulophid parasite, *Dasyscapus parvipennis*, Gahan, which during periods of heavy local infestations may parasitise as many as 80%. The writer was unable to find any sign of the presence of this parasite in San Thomé.

In Fernando Póo and the Belgian Congo a small black ant, *Rhoptromyrmex* (*Acidomyrmex*) sp., commonly infests cacao trees. Nests are constructed between two adjacent leaves, and consist of mud and excrement, etc. The ants are extremely active, and can be found searching for other insects on which they prey on all parts of infested trees and contiguous trees. Thrips are rarely observed on trees infested with these nests. This ant was not observed in San Thomé.

As the parasite, *Dasyscapus*, forms such an important check on the mainland it would be of immense value, in the opinion of the writer, if the San Thomé Government were to put experiments in hand in an attempt to establish it in the Island. Experimental work in connection with its life-history and habits would have to be undertaken in the country of origin and also as to the best methods of transportation.

Cultural conditions, believed to have been responsible for the increase of Thrips, are being corrected. In the north shade-trees are being replaced and wind-breaks being put in where necessary. One of the main requirements of a shade tree is rapid growth. By far and away the best tree tried so far is *Albizzia moluccana*, which will reach a height of from 50 to 60 feet, with the necessary lateral growth, in six years. In the south the soil on the steeper slopes is being retained by the planting of cover crops, the best results being obtained from *Vigna oligosperma*. On some plantations a slight lessening of attack has resulted.

As far as the Gold Coast is concerned there is no danger of Thrips reaching anything like the same proportions as in San Thomé. There are naturally bound to be occasional periods when this pest will be more severe than in other years, as is common with any other insect pest, owing to some climatic or other factor favouring its increase or unfavourable to the corresponding increase of natural enemies. Conditions unfavourable to the growth of cacao, such as bad soil, exposure, causing irregular humidity, will result in what is known as "Die-back," a physiological condition associated with Thrips attack. In the past Thrips has been held responsible for a large amount of damage that has been nothing more than "Die-back."

SUMMARY.

1. *Heliothrips rubrocinctus* has only been recognised as a pest in San Thomé since 1916.

2. As a result of attack exports have fallen nearly 50% since 1917.

3. It has been stated that attack is due to drought conditions such as might occur in the north of the Island, coupled with the destruction of protective shade and wind breaks. This is obviously not the only factor, as Thrips is more severe in the southern part of the Island, where humidity conditions are, if anything, excessive.

4. A recent introduction of this pest is indicated in view of the fact that its increase has been of recent occurrence and that the Eulophid parasite, *Dasyscapus parvipennis*, Gahan, of the Gold Coast, does not occur in San Thomé.

5. In this connection it is significant that certain well-known pests of the mainland are absent, San Thomé obviously owing its immunity to its isolation.

6. It is also significant that where similar conditions occur on the mainland Thrips is only a minor pest.

7. In the writer's opinion, an efficient control would be obtained by the importation of *Dasyscapus* from the mainland. There should be little difficulty encountered in establishing it.

8. There is no danger of *Heliothrips rubrocinctus* reaching the same proportions in the Gold Coast.

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APPENDIX

RAINFALL TABLES

I. Fernando Póo (Rio Tiburones, Sampaka and Bococo)

II. San Thomé (City)

III. San Thomé (Rio de Ouro)

IV. San Thomé (San Miguel, Burnay, Johanna de Souza)

V. Belgian Congo (Ganda Sundi)

VI. Belgian Congo (Urselia)

VII. Belgian Congo (Lukolela and Eala)

VIII. Belgian Congo (Barumbu)

I.

Fernando Póo.

Month.	Rio Tiburones, near Santa Isabel (Northern end of Island).								Sampaka (1 kilometre from Rio Tiburones).				Bococo, near San Carlos (Western side of Island).											
	1923		1924		1925		1926		1927		1928		1923		1924		1925		1926		1927		1928	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January ...	—	—	2.28	7	0.00	0	0.22	1	4.48	—	8.05	18	—	—	1.24	—	0.00	0	0.76	2	1.62	4	4.16	5
February...	—	—	4.44	5	0.48	3	0.68	2	6.16	—	6.42	14	—	—	2.76	—	0.76	2	1.96	4	2.72	4	0.00	0
March ...	—	—	11.40	14	13.36	11	8.67	7	10.28	—	10.28	16	—	—	4.32	—	11.88	10	1.92	2	1.84	4	1.96	5
April ...	—	—	7.68	13	5.40	14	7.08	11	7.28	—	5.96	3	—	—	4.68	—	3.86	10	3.76	4	3.44	7	3.04	6
May ...	7.56	24	8.08	16	10.12	18	4.92	12	7.92	—	8.30	16	—	—	5.62	—	7.64	7	5.28	10	2.88	8	11.74	9
June ...	9.60	15	13.16	21	12.00	14	15.44	16	11.40	—	16.06	16	—	—	13.02	—	5.32	8	14.68	9	8.18	12	9.32	11
July ...	4.32	12	21.36	24	13.60	16	14.18	14	16.48	—	25.02	28	11.68	—	37.58	—	17.76	17	17.16	8	21.80	16	35.80	12
August ...	11.64	18	30.80	26	20.20	21	23.04	17	18.00	—	11.12	22	24.90	—	39.46	—	55.68	19	27.56	18	28.12	22	29.56	20
September	16.08	21	12.24	20	20.04	23	5.64	12	12.32	—	—	—	16.10	—	19.74	—	25.84	20	12.32	14	27.56	13	—	—
October ...	9.60	16	16.44	25	17.36	23	5.88	11	0.44	—	—	—	7.78	—	14.08	—	15.56	13	5.68	9	3.44	9	—	—
November	5.04	7	4.12	11	4.48	11	—	—	0.00	—	—	—	5.14	—	2.00	—	4.12	6	1.72	7	0.00	0	—	—
December	2.12	3	0.96	5	0.00	0	—	—	0.80	—	—	—	0.96	—	2.28	—	0.16	1	0.00	0	3.12	2	—	—
Total ...	—	—	132.94	185	117.14	164	—	—	97.92	—	—	—	—	—	146.78	—	148.58	114	92.80	87	104.72	101	—	—

II

San Thomé City.

Month.	Average 1877–1881		1917		1918		1919		1920		1921		1922		Average 1917–1922	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January ...	3.90	9	2.50	10	4.81	7	4.33	10	1.00	2	0.62	4	0.80	5	2.34	6.3
February ...	4.27	7	4.20	10	4.82	6	1.19	1	3.42	6	1.26	4	4.05	6	3.15	5.5
March	6.05	10	3.94	5	6.41	10	0.00	0	1.60	6	5.16	10	1.79	3	3.16	5.6
April	5.86	10	3.77	8	9.26	11	6.95	8	5.15	10	1.44	9	7.81	13	5.73	9.8
May	4.39	8	6.18	15	0.83	4	0.66	2	5.92	7	4.86	9	4.24	6	3.78	7.1
June	0.88	1	2.42	7	0.00	0	0.00	0	0.00	0	2.25	1	0.07	1	0.79	1.5
July	0.00	0	0.04	2	0.00	0	0.00	0	0.00	0	0.20	1	0.00	0	0.04	0.5
August ...	0.03	1	0.03	1	0.00	0	0.00	0	0.07	1	1.14	2	0.00	0	0.20	0.6
September ...	0.89	5	1.09	1	1.12	2	0.00	0	0.35	2	9.41	12	0.19	2	1.86	3.1
October ...	4.87	9	1.47	8	0.59	2	0.22	1	0.68	4	7.96	17	1.32	9	2.04	6.8
November ...	6.30	10	7.15	9	4.76	9	1.69	2	2.06	8	5.77	8	2.93	7	4.06	7.1
December ...	2.18	5	1.31	4	3.94	8	2.27	8	2.27	6	2.14	5	3.93	7	2.83	6.5
Total ...	39.62	75	34.10	80	35.54	59	17.31	32	23.65	55	42.21	82	27.13	59	29.99	60.8

Taken from "Short Report on the San Thomé Cacao Pest," W. H. Patterson, Accra, 1923.

III.

San Thomé.

Rio do Ouro (Sede) (North of Island).

Month.	1916		1917		1918		1919		1920		1921		1922		Average 1916–1922	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January ...	6.25	18	4.22	11	7.89	11	7.29	13	1.45	4	0.75	4	0.53	5	4.34	9.5
February ...	10.69	12	6.95	13	8.83	8	2.12	4	3.67	4	3.31	5	4.13	6	5.53	7.4
March	2.92	10	6.09	7	4.98	11	3.78	6	2.71	9	6.41	13	2.56	10	4.20	9.5
April	7.79	17	3.45	9	8.65	15	4.67	8	9.50	14	6.81	17	4.09	13	6.42	15.5
May	5.63	8	16.06	17	1.44	6	8.11	4	9.57	12	5.31	13	6.65	12	7.55	10.3
June	0.00	0	4.83	6	0.00	0	0.00	0	0.35	1	1.34	2	0.00	0	0.93	1.3
July	0.56	3	0.00	0	0.00	0	0.00	0	0.00	0	0.22	4	0.00	0	0.11	1.0
August ...	0.00	0	0.49	4	0.10	1	0.03	1	0.00	0	0.42	2	0.00	0	0.13	1.1
September ...	0.21	4	7.67	3	0.34	4	0.19	3	0.04	1	9.09	16	6.65	6	3.45	5.3
October ...	9.91	17	8.09	16	1.63	6	0.34	4	2.29	8	9.92	20	0.87	12	4.72	11.9
November ...	15.59	16	8.52	8	7.65	14	1.79	5	3.55	9	6.70	13	3.78	8	6.79	10.4
December ...	10.17	9	2.36	10	5.65	13	3.04	8	6.32	9	4.72	9	4.37	11	5.23	9.8
Total ...	69.72	114	67.73	104	49.16	89	31.36	56	39.45	71	55.00	118	33.63	83	49.43	90.7

Taken from "Short Report on the San Thomé Cacao Pest," W. H. Patterson, Accra, 1923.

IV.

San Thomé.

Month.	San Miguel (Southern part of Island).				Burnay (Southern part of Island).				Johanna de Souza (Southern part of Island).			
	1921		1922		1921		1922		1921		1922	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January	13.74	18	27,71	22	13.50	15	29.49	14	12.80	14	22.75	9
February ..	13.54	13	25.63	20	11.81	11	34.56	18	11.97	14	32.40	14
March	10.47	21	30.39	13	10.31	19	22.83	16	7.56	14	22.95	15
April	8.93	16	36.41	20	16.92	12	38.03	20	27.12	17	48.38	21
May	22.36	19	34.64	23	29.56	20	43.85	21	24.84	21	22.00	18
June	1.73	6	3.19	11	3.42	5	6.33	8	2.95	5	6.22	8
July	30.66	11	1.38	7	5.63	10	2.95	9	1.73	2	1.81	7
August	7.48	17	1.81	10	14.92	20	3.78	14	7.16	10	3.58	13
September ..	39.13	28	15.43	25	48.97	28	2.49	27	37.32	26	23.58	27
October	57.48	31	48.03	28	78.11	31	54.96	29	59.92	27	46.97	29
November ..	57.48	28	44.37	30	58.85	24	48.50	27	56.10	21	40.08	27
December ..	79.33	29	31.69	27	64.96	25	39.72	23	34.25	18	28.11	22
Total	342.33	237	300.68	236	356.92	220	327.49	226	283.72	189	298.83	210

Taken from "Short Report on the San Thomé Cacao Pest." W. H. Patterson, Accra, 1923.

V.

Belgian Congo.

Ganda—Sundi—Mayumbe (Lower Congo).

Annual rainfall from 1910 to 1920 inclusive.			Month.	1921		1922		1923		1924		1925		1926		1927		1928	
Year.	Rain.	Days.		Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
1910	52.70	84	January ...	6.36	No record.	0.87	No record.	11.53	No record.	5.64	No record.	7.67	No record.	8.91	No record.	5.11	14	7.32	23
1911	50.94	77	February ...	4.02		6.96		10.00		6.70		7.38		13.30		6.54	19	2.96	23
1912	73.10	101	March	8.77		8.43		8.34		13.84		1.75		12.46		6.21	23	4.42	18
1913	47.73	68	April	11.93		11.68		2.49		16.32		10.62		4.41		9.68	27	6.70	28
1914	52.70	108	May	0.63		3.03		6.16		2.17		1.56		2.24		7.44	20	6.59	15
1915	51.52	79	June	0.08		0.04		0.21		0.09		0.08		0.12		0.04	5	0.01	2
1916	72.52	128	July	0.00		0.12		0.12		0.56		0.06		0.14		0.14	7	0.00	0
1917	46.31	96	August ...	0.18		0.12		0.00		0.21		0.11		0.10		0.25	12	0.22	11
1918	39.31	79	September ...	7.52		0.39		0.20		0.70		0.28		0.74		0.25	10	1.37	25
1919	44.22	77	October ...	4.02		2.68		1.87		14.29		1.29		1.15		2.88	19	2.06	22
1920	62.28	119	November ...	1.60		0.89		9.66		7.70		7.35		7.10		12.62	18	10.10	21
			December ...	1.18		12.14		5.73		4.31		13.24		1.72		6.51	16	7.44	23
				46.29		47.35		46.31		72.53		51.41		52.29		57.73	190	49.19	221

VI.

Belgian Congo.

Urselia—Mayumbe (Lower Congo).

Month.	Average. 1904 to 1908 inclusive.		Average. 1909 to 1913 inclusive.		1914		1915		1916		1917		1918		1919		1920		1921	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January ...	11.95	10.2	6.06	9.5	7.36	9	2.08	4	7.92	15	5.14	14	3.48	6	2.97	4	9.22	10	4.73	12
February ...	8.49	9.8	10.16	13.2	2.44	4	0.04	1	10.92	12	9.50	12	3.51	9	0.59	2	8.53	8	1.87	7
March ...	14.49	14.2	7.87	12.7	4.08	11	7.04	14	4.87	10	8.00	10	4.50	11	0.90	4	3.34	7	20.06	16
April ...	17.89	14.0	9.78	15.2	6.52	23	8.47	17	8.33	13	6.33	12	15.74	21	1.39	8	17.98	16	11.26	16
May ...	5.33	9.2	5.37	10.2	2.79	14	1.79	4	1.14	8	7.65	13	2.38	4	0.32	6	1.98	12	2.17	10
June ...	0.52	1.2	0.00	0.0	0.47	11	0.09	2	0.00	0	0.00	0	0.00	0	0.16	3	0.13	3	0.00	0
July ...	0.06	1.0	0.08	1.0	0.07	1	0.05	1	0.04	1	0.00	0	0.39	4	0.04	2	0.07	3	0.02	1
August ...	0.36	4.4	0.12	3.5	0.34	9	0.13	5	0.05	1	0.42	8	0.17	2	1.97	8	0.16	3	0.08	4
September	3.88	16.4	0.88	7.4	0.65	11	1.30	14	1.08	12	0.38	7	0.60	7	0.80	19	0.42	7	0.42	10
October ...	6.40	16.8	5.06	13.4	8.84	16	1.58	13	8.38	24	0.91	5	0.56	10	3.41	19	1.16	15	2.99	11
November	23.06	18.8	8.97	14.8	4.51	16	14.38	20	9.97	21	3.30	7	9.60	13	14.30	17	14.68	21	1.40	9
December	12.74	13.4	7.85	14.0	4.50	8	13.46	22	16.42	19	3.70	9	9.78	18	10.02	19	10.53	19	1.16	3
Total ...			63.75	114.9	42.57	143	50.41	117	69.12	136	45.33	98	50.71	105	36.87	111	68.20	124	46.16	99

VI—*continued.*

BELGIAN CONGO.

URSELIA—MAYUMBE (LOWER CONGO) (*continued*).

Month.	1922		1923		1924		1925		1926		1927		1928	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January ..	1.46	7	8.27	16	13.99	18	3.36	11	7.26	18	3.57	10	8.51	9
February ..	3.33	8	13.48	9	3.54	9	6.06	13	7.48	19	8.18	12	3.02	7
March	9.40	15	7.81	12	8.97	15	5.92	7	10.74	16	2.57	9	3.31	6
April	9.19	18	8.49	11	12.32	13	7.80	13	5.24	10	5.66	10	11.54	15
May	1.80	10	6.41	10	3.06	4	0.92	5	3.97	3	3.48	9	6.30	6
June	0.04	2	0.07	6	0.02	3	0.00	0	0.01	2	0.00	0	0.00	0
July	0.03	2	0.25	4	0.04	3	0.05	1	0.03	1	0.00	0	0.00	0
August ..	0.25	7	0.04	3	0.06	1	0.02	2	0.15	4	0.13	2	—	—
September ..	0.34	17	0.12	1	1.37	9	0.15	6	1.50	15	0.27	4	—	—
October ..	1.85	13	1.33	20	6.72	19	1.04	13	1.19	17	1.48	11	—	—
November ..	4.96	13	9.57	18	8.41	19	8.77	22	11.12	22	6.49	13	—	—
December ..	11.55	9	5.07	12	4.07	11	9.54	20	0.23	2	3.97	8	—	—
Total ..	44.20	121	60.91	122	62.57	124	43.63	113	48.92	129	35.80	88	—	—

VII.

Belgian Congo.

Month.	Lukolela—Province Equatoriale.							Eala—Province Equatoriale.													
	1920	1921	1922	1923	1924	1925	1926	Average, 1911–1915 inclusive.		1917		1918		1919		1920		1921		1922	
	Rain.	Rain.	Rain.	Rain.	Rain.	Rain.	Rain.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
Jan.	—	5.42	2.74	3.15	10.49	4.14	3.01	3.87	7.4	3.79	11	2.58	6	9.17	12	2.12	4	2.96	9	4.06	9
Feb.	—	0.96	6.95	3.86	3.07	6.77	4.87	6.61	7.4	8.68	9	2.67	9	2.41	9	3.42	4	5.36	9	5.40	6
March	—	5.86	6.24	5.42	1.60	1.26	5.96	4.52	8.8	6.50	5	8.34	13	2.81	8	4.57	8	2.30	7	7.40	10
April	6.80	6.28	4.60	6.34	5.64	6.00	3.49	4.82	9.8	3.69	9	7.53	15	4.19	12	4.16	7	9.03	15	6.66	18
May	9.02	3.54	4.13	8.44	5.84	10.35	2.84	8.19	11.8	10.61	13	5.65	18	7.97	13	10.60	15	5.14	12	6.50	20
June	0.12	3.29	1.85	3.74	4.10	2.12	3.32	4.85	8.2	7.03	7	3.55	8	7.77	9	3.88	4	3.83	8	7.25	11
July	1.68	0.30	0.22	0.28	2.31	1.65	0.30	3.49	4.5	1.91	4	6.34	9	3.34	6	5.60	5	2.95	7	3.62	4
August	2.66	1.28	2.61	3.36	7.34	3.70	0.94	5.11	7.0	8.79	8	8.62	13	12.63	9	2.67	9	6.14	12	3.34	7
Sept.	7.32	10.22	3.60	7.20	1.78	8.32	5.44	8.09	15.0	6.92	8	2.76	14	7.34	14	5.32	12	11.00	11	7.24	15
Oct.	7.95	7.33	6.40	4.02	13.74	7.63	7.78	9.35	16.4	15.33	9	7.34	21	7.37	18	4.62	13	9.18	15	11.15	22
Nov.	1.70	7.03	7.29	2.43	5.31	2.36	10.25	9.11	12.8	7.42	16	4.98	19	3.74	12	5.94	15	5.48	12	5.71	16
Dec.	7.86	2.33	4.31	3.39	5.69	13.28	9.66	7.10	11.2	8.26	11	10.84	12	9.42	13	5.92	11	4.85	14	4.87	15
Total		53.84	50.94	52.63	66.91	67.58	57.86	75.11	120.6	88.93	110	71.20	157	78.16	135	58.82	107	68.22	131	73.20	153

VIII.

Belgian Congo.

Barumbu—Equator (Province Orientale).

Month	1916		1918		1919		1921		1922		1923		1924		1925	
	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.	Rain.	Days.
January ...	2.05	2	1.17	2	6.54	9	1.14	5	5.44	5	3.05	3	2.35	4	1.23	2
February ...	4.42	6	2.68	4	5.45	8	2.57	3	1.58	5	2.74	4	4.12	4	3.18	4
March	4.96	10	7.59	10	8.48	9	2.83	7	4.84	4	5.89	5	6.87	8	7.10	9
April	10.46	13	8.12	12	3.46	10	5.74	13	6.56	11	7.87	6	11.68	14	8.15	11
May	2.10	7	9.03	9	5.64	9	6.75	10	5.16	8	9.33	15	4.64	7	3.47	4
June	2.97	7	7.63	15	10.20	10	6.38	14	6.43	9	5.14	7	3.49	5	7.97	10
July	4.56	11	5.37	11	5.76	12	11.35	9	7 29	7	11.07	12	9.54	7	5.73	6
August ...	3.57	13	8.09	16	4.54	10	8.38	14	6.54	9	7.17	9	3.74	7	5.05	7
September ...	7.97	12	9.25	9	5.87	11	5.20	12	7.53	7	11.42	10	7.05	7	12.81	10
October ...	7.95	17	7.45	13	3.28	8	8.55	19	11.20	9	5.94	10	4.65	9	14.51	14
November ...	9.07	13	7.53	10	7.34	12	5.74	11	9.45	8	12.82	10	6.43	8	5.50	6
December ...	4.60	9	5.60	14	4.65	10	5.00	8	7.04	7	4.77	6	8.19	9	5.14	5
Total ...	64.68	120	79.51	125	71.21	118	69.63	125	79.06	96	87.21	97	72.75	89	79.84	88

PAPER No. XV.

FIELD TECHNIQUE IN CONNECTION WITH YIELD TRIALS IN THE DAGOMBA DISTRICT.

By G. COWAN.

The whole theory of modern Field Technique and Statistical Methods is based on one approved principle. It is generally agreed that " small contiguous or closely adjoining plots tend to resemble one another " (Ref. " Principles and Practice of Yield Trials," by Engledow and Yule). The block and plot system of Field Experimentation has been devised to make use of the generalisations from this fact to the fullest advantage, and at the same time by so doing to reduce both the area required for the whole trial and also the number of replicated plots. If carried out properly the same accuracy is obtained with a few replicates, as would be the case if a very much larger number of replicates were used in a less systematised experiment. " Systematised or controlled randomisation," therefore, seems to meet the case. By dividing the area into blocks so that the plots inside each block are kept relatively small, sudden changes of soil types are infrequently met with. In other words, the soil in each block is relatively homogeneous, and, accordingly, the plots in each block do not vary materially from each other. On the other hand, when blocks are considered as a whole and compared with each other on the basis of the crop yield, it is frequently, or indeed almost invariably, found that large differences exist. That is, when large areas are considered, the expectation is that the large variation in soil types met with will give rise to large variations in yield.

Putting this in different words: while the variance between the blocks is almost always large, the variance between plots in the same block which receive similar treatment is relatively small.

In practice, however, it has been found that it is not practicable to reduce the size of plots too much. They must be of sufficient size to be workable, and to counteract as far as possible uncontrolled factors which may not be general over the area. Even more important, they should be large enough to decrease personal or human factors. Under conditions such as exist in the Northern Territories it would appear to be necessary to make plots larger than those in temperate countries. The reason for this is found in the unskilled labour and the difficulties of supervision which exaggerate the per-

sonal factors. For example, planting, different cultural treatments, and other operations, have to be carried out as uniformly as possible in the replicated plots. In practice a high degree of uniformity is not always obtainable where only hand labour can be employed. The cultivation of a crop is carried out by a squad of men, and each of the individuals in the squad do not perform the operations in an exactly similar manner. The members of a labour gang ridging do not, for example, make exactly identical ridges. This, of course, introduces other unwanted factors into the experiment which would be avoided to a large extent if machinery could be employed. Therefore because of these "controllable" factors, which in the tropics are only controllable in direct ratio with the efficiency of skilled labour and trained supervision obtainable, it would seem that plots must necessarily be made larger. In this way differences due entirely to the non-uniformity of cultivations would be masked, and each man's work, with its special characteristics, would be spread more generally over the area of the trial. In other words, the individual work of each member of the labour gang should be randomised over the trial.

Cases of petty theft from growing crops which cannot always be prevented, *e.g.*, the removal of a few cobs of maize from a particular plot, small errors in weighing the yield, the effect of the shade of isolated trees (and also the manurial effect of "dawa-dawa" trees (*Parkia filicoidia*) are masked or rendered relatively small if large plots are used.

Even when complete randomisation of plots within the blocks is effected (as should be the case) a high degree of accuracy cannot be obtained by using plots which are too small.

The opinion is therefore tentatively advanced that the minimum size of ridged plots, regardless of the kind of crop to be grown, should be one-tenth of an acre. The type of soil, nature of experiment, kind of crop, and skill of the labour gangs must be considered in arriving at the best size of the plots.

Since "small contiguous or closely adjacent plots tend to resemble one another," it is inadvisable to separate these plots more than is absolutely necessary because of the contour of the land.

The difficulties are increased when it is realised that plots should be of similar *shapes* as well as of similar areas. In addition, they should be separated by similar paths. If these points are not recognised and suitable measures not adopted, then it is evident that another unwanted factor—that of "Edging" or Border Effects—is introduced. In practice the simplest way to combat this factor is to make the plots rectangular. The problem now resolves itself into one of fitting these plots into the contours of each particular block, so that the plots are adjacent and are separated by paths of equal dimensions. In addition, the plots should not be subjected to

"washing," so it is evident that the problem is a complex one, and the measures taken to combat it should be such that :—

(*a*) The introduction of human or personal factors should be avoided. (Plots should be large enough to be workable with the kind of labour and supervision which exists.)

(*b*) Plots are of equal area and equal shape and are divided by equal paths. (Rectangular plots appear to be most suitable.)

(*c*) Soil erosion and washing does not take place and, at the same time, suitable drainage is effected.

In a country such as the Gold Coast, where European plantations are the exception rather than the rule, only relatively large differences in the yield of crops due to different treatments need, in the first instance, be investigated. It follows, therefore, that some factors which would have a large effect if small differences were regarded can be neglected. It is, of course, desirable that results should be as accurate as possible, but by laying too much stress on the small factors it is possible to lose sight of the main problems. By attempting too much with relatively unskilled labour in the tropics, it is easy to become immersed in the theoretical intricacies to ensure accuracy. Artificial measures to counteract these personal factors may even defeat their own ends by introducing other less apparent factors. It follows, therefore, that practical difficulties should not be placed in the way, and consequently that experiments should be as simple and as "foolproof" as possible. Later, when the main problems have been satisfactorily elucidated, smaller differences may be investigated. It then becomes necessary to pay more attention to the smaller factors, which now become vital.

The above three points are, however, considered to exert a large enough effect on crop yields to warrant attention in *all* experiments. Whether large or small differences in yields are being considered, their effect is by no means negligible. Those dealing with cultivations are, of course, the most important, but the others cannot be neglected. The following methods to deal with them are, therefore, tentatively advanced.

(1) Where a large area exists it becomes relatively simple to follow the block system on those portions where the main direction of flow of water is at right angles to a pair of opposite sides. Water channels can be constructed in those places where the contour of the land permits. The requisite number of blocks may be fitted into the contours so that the surplus water can be led away down the water channels. It thus happens that blocks might be widely separated. Inside each block the plots are now fitted; they are separated by paths of equal dimensions, and small drains are constructed in those paths to lead the water

from each plot to the main water channels round the blocks. Each plot is now ridged according to its special features. The portions of the area where the direction of flow of the surplus water changes to a marked degree cannot, however, be used for experimental purposes. This constitutes a grave disadvantage from a practical point of view. Besides being difficult to mark out, a patchwork system of cropping is not favourable to future experiments on the same ground, since the aim is to reduce the Experimental Error as much as possible in all experiments.

(2) When the ground is level or on a very gentle uniform slope, and where the soil is very permeable, the following method may be adopted. Ridging over a compact area is carried out parallel to the sides of the piece of ground which slope least, *i.e.*, the ridges run almost along the main contours but small variations are disregarded. Blocks, plots and paths are marked out after ridging and, in addition, "stops" or banks of earth, 2 feet thick, are placed across the ridges at varying intervals, according to the gradient. Where the gradient along ridges is steep the stops should be relatively closer together. The surplus water will, therefore, remain in each furrow and should sink into the ground instead of flowing down the slope. The stops across each end of the furrow, and also at the varying intervals along the furrow, should be made slightly lower than the ridge, so that in times of particularly heavy rain these stops may be broken down to allow the accumulated water to run into the drains and water channels without breaking down the ridges. Fewest practical difficulties are encountered in this method, but it can be applied only when, as pointed out before, the ground is relatively level and the soil is of a permeable nature. The following are the dimensions of ridges and furrows which are most widely used on the Investigational Station.

Area of cross-section of furrow = 168 square inches (8 inches deep, 24 inches width at top and 18 inches wide at bottom). Breadth of catchment area for each furrow = 48 inches (*i.e.*, distance from centres of two adjacent furrows). For any length of ridge the capacity of the furrow is such that, on level ground with the ends of the furrow blocked, 3.5 inches of rain can fall without any of the water overtopping the ridges.

If the ground slopes and a "stop" is placed across the furrow at each fall of 8 inches, the capacity of the furrow is such that 1.75 inches of rain may fall on the same catchment area without water overflowing over the tops of ridges.

By putting in stops at every fall of 4 inches along the furrow, the capacity of each section of the furrow is increased, and now is such that 2.5 inches of rain may fall on the same catchment area.

These figures do not allow for any proportion of the rainfall sinking quickly into the ground. In sandy and gravelly soils the proportion is naturally higher than on clay soils. When calculating the factor of safety to be used this must be taken into consideration. In addition, allowance should be made for the reduced capacity of furrows on account of the soil which is washed off the top of the ridges. By judiciously placing these stops or by deepening the furrow, or by altering the breadth of both ridge and furrow, it is possible to provide exactly for either the maximum expectation of rainfall or alternatively for any desired rainfall.

(3) Since the topography of the Northern Territories is typically undulating with long, gentle slopes, the following method should suit those places which do not conform with the provisions in (2). Blocks, plots and paths should be marked out in a compact area before ridging. When completed, each plot is taken individually and ridged according to its special or peculiar characteristics. Those water channels which run in the direction of swiftest flow should be made continuous and should cut across the paths at right angles. The plan which is to be found on the following page will make the scheme clear.

It will be noticed on the plan that :—

(1) The general direction of flow is from north-west to south-east.

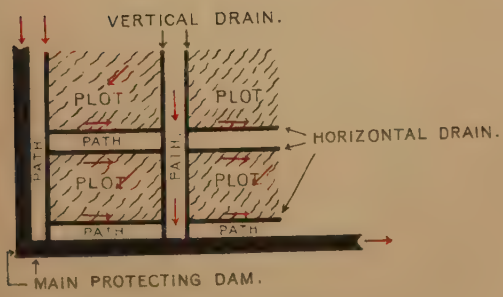
(2) The water runs from north to south in vertical or main drains.

(3) The water in the horizontal or cross drains runs from west to east.

It is essential that the main and cross drains should be cleaned out frequently. These drains must not be made deep, but a certain amount of silting is unavoidable if the soil is of a loose light nature.

It is impossible to give exact dimensions of plots, paths and drains, since every particular soil has to be judged on its merits. The optimum sizes can only be arrived at by trial. In addition, the kind of crop grown, the type of experiment, and the degree of proficiency of the labour, particularly determine the size of plots to be used. It should be remembered that the figure one-tenth of an acre, given before, only represents the minimum, and, accordingly, has not necessarily any connection with the optimum size.

PLATE I.



MAIN DIRECTION OF SLO

Survey H.Q. Accra, 1930.

It is advisable that the area of ground should be adequately protected from surplus water from the surrounding ground. These protecting drains must necessarily be wide in light sandy soils, but need not necessarily be deep. They must have, however, sufficient fall to carry the water away quickly. If a line of seepage occurs within 1 foot of the surface it is advisable to make the protecting drains of such a depth that this seepage water is trapped and part at least made to flow into the drains instead of down the experimental area. When rice is grown this precaution is neither necessary nor advisable.

A refinement in the laying out of trials would be to leave a strip of ground vacant between the protecting drains and the path round the trial itself. This would counteract any drying-out effect of the relatively deep protecting drains on the adjacent soil. This effect is, however, only noticeable in the early part of the rainy season.

PAPER No. XVI.

AGRICULTURE IN THE KETA-ADA DISTRICT.

By J. T. H. STEIN.

In studying agricultural conditions in any district certain factors, which are limiting factors in agricultural and crop production, must be considered. These are the climatic conditions in general of the district, and rainfall in particular, the type or types of soil found, the population and its distribution, and, finally, the roads and means of communication.

Taking these factors into consideration, the Keta-Ada district is divided into three well-defined areas.

(a) A Very Dry Coastal Belt.

This is specially marked in the Keta district in the narrow sandy strip of land lying between the sea and the lagoon and stretching from the Volta River to Aflao on the French Togoland frontier, a distance of 49 miles. The main crops in this dry belt are coconuts, onions, sugar cane, cassava and beans. Live-stock consists of sheep, goats and pigs, while the poultry industry, especially in the case of ducks and turkeys, is of considerable importance. This is the most densely populated area of the whole district, a large proportion of the male population gaining a livelihood by fishing.

(b) Dry Interior Area.

This " dry farming " area forms the greater part of the district, stretching, as it does, from behind the lagoon to the north of the Keta district and to the west across the Volta into the Ada district, almost the whole of which falls into this category. The land is flat, and few rivers or streams are to be found in this area, but the mean annual rainfall is greater than that of the coastal belt.

The main crops are food crops, the most important being maize, cassava, beans, groundnuts, sweet potatoes, tiger nuts * and Bambarra nuts. A little cotton is grown, and this area would appear to be quite suitable for growing that crop, but the population is rather small and scattered. The live-stock industry is of great importance, many large herds of cattle being found throughout the area.

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* Cyperus esculentus.

(c) Oil-Palm Belt.

This oil-palm belt, which is found in the north-east and north of the Keta district, continues to the north into the Ho district. The centre of the belt is Djoje, which is 16 miles from the coast. This area receives a greater annual rainfall than any other part of the Keta-Ada district, and in consequence is the best farming area in the district, in that it is capable of greater crop production than any other part.

The main crops, besides oil palms, are yams, maize, cassava, groundnuts, fruits and vegetables. Little live-stock is found in this area.

AGRICULTURAL INDUSTRIES OF THE DISTRICT.

The main agricultural industries carried on in the Keta-Ada district are the coconut, oil palm, onion, food-crop, live-stock and poultry industries.

A. THE COCONUT INDUSTRY.

Coconut palms are found growing in an almost continuous belt from Atiteti to the French Togoland frontier, along the narrow coastal strip lying between the sea and the lagoon, while on the mainland side of the lagoon a large area of coconut palms is found between Agbosome and the lagoon and around Aferingba. In Ada district there is a belt of palms between Ada and Pute, but the coconut industry is of little importance there as compared with the Keta district.

Cultivation of Coconuts.

It is the exception rather than the rule to find nuts planted at stake, the usual method being to raise seedling palms in nursery beds and transplant these later. The method of raising seedling palms is of interest : ripe nuts are picked from the trees and, after having been kept for a period, are in some cases put into water to soak thoroughly, with the idea of hastening germination. They are then planted in a so-called nursery bed, which consists of a large shallow hole in which all the nuts are planted and covered with a little soil. When the seedling palms have got three leaves, in about six to eight months' time, they are transplanted, the nuts being planted 1½ to 2 feet deep and about 20 feet apart. The distance apart varies and planting in lines is rarely done.

Young palms receive periodical manuring, hoeing and mulching, and on a good soil and where receiving attention commence to bear fruit about the sixth year. Under poorer conditions the palm may take eight to ten years before fruiting, while there are cases in the coastal strip of much older palms never having borne fruit, due either

to extreme poverty of the soil or to the fact that the water level is very near the surface of the ground.

The thriving and vigorous state of palms around the villages is very noticeable. This is due to the fact that such palms receive more attention and are regularly manured with sheep and goat manure and house-yard sweepings. In the Agbosome district the following method of manuring is practised: a very shallow circular trench is made round the palms, cattle being tied in these in the afternoons to rest and the manure hoed into the ground later.

Harvesting usually takes place every three months, although in many cases unripe nuts are plucked and used for making copra.

Products of Coconut Industry.

The most important crop in the district is undoubtedly coconuts, for not only does the crop provide food and fuel for the native, but also from it is produced the most valuable economic product of the district, namely, copra. Other products of the industry are coconut oil and fibre, the coconut husks also being used extensively in place of firewood.

(*a*) *Copra.*—Practically all the copra exported from the district is produced in the Keta district, very little being produced on the Ada side of the Volta, as in that district the coconut grower finds it more profitable to ship fresh coconuts up river and to sell these in Akuse and other places.

At the moment an average of 1,400 tons of copra is exported from the ports of Keta and Denu annually. While this is likely in the future to increase to a considerable extent, it would appear unlikely that the average exported tonnage per annum will ever rise much over 2,500 tons. There is not a great deal of land available now for planting along the coast, and it is on the mainland side of the lagoon that extension will have to take place. It must be remembered also that very considerable numbers of fresh coconuts are consumed daily by the natives as food, the coconut milk being used as a substitute for water, drinking water being a rather scarce commodity in the coastal district, and the number of coconuts used for these purposes is not likely to decrease.

Unfortunately copra exported from the district is of very inferior quality and has gained an unenviable reputation on the home market. Copra production is entirely in the hands of the peasant farmer, who sells his produce to the merchant or his agent. At the moment, as regards copra buying, there is no competition among trading firms, all European and most other agents refusing to buy owing to the very poor quality of the produce.

The main defects are:—

(1) *Mouldy copra*, due to insufficient and careless drying; for example, lack of protection at night from the dew.

(2) *Discoloured and soft copra*, due to utilisation of unripe nuts.

(3) *Copra covered with sand and dirt*, due to carelessness during the drying period.

It is apparent that these defects are all remediable by the producer, and, that being so, it must be assumed that either the producer is ignorant of the proper methods of preparation or he is too lazy to give the time and care necessary for the preparation of good quality produce. There are, therefore, two methods by which improvement in quality may be effected: firstly, by instructing producers in proper methods of preparing copra; and, secondly, in conjunction with this, by the introduction of a strict system of copra inspection, similar to the system of produce inspection in force in French Togoland.

In French Togoland compulsory produce inspection is in force, all kinds of produce having to be inspected and, if up to the required standard, passed by an inspector before it can be bought by a merchant. If the defects of copra are all remediable by the producer, the time for inspection is certainly before the produce is bought by the merchant. Buying and inspection centres have been formed in the various districts in French Togoland, with a native inspector in charge of each post, all being under the control of a European Chief Inspector in Lome. The benefit of such a system is seen in the excellent quality of produce which is exported from French Togoland. Keta copra is very inferior to Lome copra, the difference in price paid by the merchant attesting to that fact. Prices at the moment are:—

Lome	£17 10s. per ton
Denu	£15 ,,
Keta	£14 4s. ,,

In the Keta district the copra-producing area is confined to the coastal belt and the Agbosome district, that is, the producing area is small and compact and has the great advantage that no part of the producing area is far from the export centres of Keta and Denu. It would be comparatively easy, therefore, to introduce into the district a system of copra inspection similar to the French Togoland system. Such a system is definitely desired by, and would have the support of, the merchants and chiefs of the district.

(*b*) *Coconut Oil.*—Coconut oil is prepared both from fresh nuts and copra. The method of preparation is as follows: the kernel is grated or beaten in a mortar, after which treatment it is put in a pot and hot water added. The contents of the pot are thoroughly mixed, when the oil forms an emulsion; after straining into another pot and boiling, the oil rises to the surface and is skimmed off. The residue left after straining is used for feeding pigs.

There is no export trade in coconut oil, all that is prepared being used locally, the market price in Keta being 4/– per gallon. It is

estimated that about three-eighths of the copra manufactured is used by the natives for producing coconut oil for their domestic and culinary needs.

(*c*) *Coconut Fibre.*—For the preparation of coconut fibre the husks of ripe nuts are used, the fibre being obtained by beating and hand picking. Fibre is used for rope making or weaving into mats.

B. THE OIL-PALM INDUSTRY.

Next in importance to the coconut industry as regards production of economic products is the oil-palm industry. As has already been stated, an oil-palm belt is found in the north-east and north of the Keta district, on the border of French and British Togoland, the centre of the belt and chief buying centre being Djoje.

Cultivation.

Planting at stake is very exceptional, the usual method being to transplant seedling palms found growing in the bush. The time of planting is from April to June, the seedling palms being planted 10 to 15 feet apart in the food-crop farms, in which may be growing yams or cassava, maize, groundnuts, okros, peppers and other vegetables. After these crops are harvested, it is usual to "catch crop" the area with cassava until the oil-palms are bearing. Plantains also are very often grown on the same area. Palms commence fruiting when three to five years old, and are in full bearing from the twelfth to twenty-fifth year. Hoeing and weeding are done during the early stages; later the ground is merely kept clear round the fruiting palms.

Products of Oil-Palm Industry.

The important oil-palm products are kernels, palm oil and kernel oil.

(*a*) *Kernels.*—Kernels are obtained after the fresh fruits are beaten and shelled, that is, after the pericarp is removed. They are then cleaned, dried and sold to the merchant, the present price paid by the merchant in Djoje being £11 10s. to £12 per ton.

On the whole, kernels produced in the Djoje district are of good quality, the main defect being the large amount of shell and dirt which is sometimes present.

(*b*) *Palm Oil.*—Palm oil, or pericarp oil, is obtained from the pericarp of the fresh palm fruits, after the fruits have been beaten in a mortar or stone-paved hole made for the purpose, sufficient warm water being added and the mixture thoroughly stirred. The following day the kernels and the residue of the pericarp are removed, the remaining surface liquid material being skimmed off, put in a clean pot and boiled until clean oil is obtained.

The price paid by the merchant in Djoje for palm oil is 7/– for 5 gallons, while in Keta market 1 gallon fetches 4/–.

The quality of palm oil produced in the district is good, the main defects being presence of water and dirt.

(*c*) *Kernel Oil.*—After cooking in a pot containing a little water, the kernels are pounded in a mortar, a little more water being added. The mixture is then transferred to a pot and boiled, when the oil rises to the surface and is skimmed off. The residue is also pressed and the oil expressed strained off. Kernel oil is made for local use only and is sold at Keta at 8/– per 1 gallon.

Of the oil-palm products, kernels and palm oil are of considerable economic importance, both being exported from the district, from Denu. The average exported tonnage of each product at that port for the last three years is :—

Kernels	426.48 tons
Palm oil	120.15 ,,

It is quite certain that these amounts do not represent the true output of the district, a considerable amount of the kernels produced around Djoje being taken across the border to Noepe, sold there and transported by rail to Lome. Noepe is only 4 miles from Djoje and is one of the French produce inspection posts. The buyer in Noepe has the advantage over the buyer in Djoje, in that he knows he is buying good quality produce, also transport by rail to Lome is cheaper than transport by road from Djoje to Denu, consequently he can afford to give a rather better price than the buyer in Djoje.

In the case of oil-palm products the French Togoland system of inspection is producing excellent results, and it would be advisable, if copra inspection was started in the Keta-Ada district on the same basis as the French Togoland system, that oil-palm products should be included, with Djoje as the inspection post.

C. THE ONION INDUSTRY.

Large beds of spring onions or shallots are to be found along the lagoon side in the region of Awunaga, which is the centre of the onion-growing industry in the district. The onions grown are of four types, large white and smaller white, large red and smaller red, the large type being about twice the size of the smaller.

Cultivation.

Beds of very fine tilth are prepared along the lagoon side and are kept continuously cropped, three crops of onions being taken per year. The farming methods practised in this case are of great interest, for in the Awunaga district the farmer has only a small area capable of growing food crops, but by introducing, as he has

done, a very intensive type of cultivation, he obtains the best possible results and greatest possible production from his land. The fertility of the soil he maintains by systematic and regular manuring.

The beds are prepared in December, any weeds or grass having been previously cut down, allowed to dry, and then dug into the soil. The usual size of bed is about 10 × 80 feet, but they vary considerably. Ditches about 1 foot deep are made between the beds for drainage purposes, these being deepened during the wet season.

The first onion crop is planted in January, the onions being planted about 6 inches apart. About three weeks after planting, maize, peppers, tomatoes and other vegetables are interplanted. The onions are harvested in March and the maize in May or June, after which the beds are manured with sheep and goat manure, house-yard sweepings and old maize stalks. The second crop of onions is planted in July, the same procedure as before, as regards interplanting other crops, being followed in this case and also with the third crop, which is planted in October. The ground is manured between the second and third crops.

After harvesting the onions are dried in the sun and then made into small bunches, a number of which are tied together to form a larger bunch, 200 being about the average number of onions in such a bunch.

The local price of onions varies from 9d. to 1s. 3d. per bunch. While large numbers are consumed locally there is a very considerable export trade in onions, large quantities being shipped up river to Akuse and from there distributed to other places. Onion growing must be considered one of the most important minor agricultural industries carried on in the district.

D. FOOD-CROPS.

The food-crops grown in the Keta-Ada district are maize, cassava, yams, groundnuts, beans, tiger nuts, Bambarra nuts, sugar cane, peppers, okros, tomatoes, and other vegetables and fruits.

The dry farming interior area is essentially the food-crop producing area of the district, although sugar cane is found growing only along the lagoon side in the coastal belt. On the other hand, yams are grown only in the oil-palm belt. The latter is also the best maize-growing area, and practically all the fruit of the district is grown in that region. Cassava is grown generally throughout the whole district, along the coastal belt as well as in the interior area. Tiger nuts and Bambarra nuts are grown chiefly in the Ada district.

Cultivation of Food-crops.

The farming methods practised in the three areas of the district vary considerably. Along the coast, where the population is dense and the area capable of producing food-crops small, the farming methods are intensive and scientific, whereas in the interior area,

where the population is scanty and there is sufficient land, an extensive and primitive type of cultivation is practised. In the latter area the ground is never manured and the farmer has only a vague idea about rotation of crops ; for example, a piece of land is kept continuously cropped with maize and cassava until it is completely exhausted. In the oil-palm belt the farmer is of a much more intelligent and progressive type, and a more intensive method of cultivation is practised.

Throughout the whole district two crops per year are grown of the annual food-crops, such as maize, groundnuts, beans, etc. Mounds are made for yams and sweet potatoes only, while onions and sugar cane are grown on large raised beds, all other crops being grown on the flat.

The maize crop is of considerable economic importance, as, along with cassava, it is the main source of supply of food for the people of the district. With the large area of maize grown, there should be sufficient to supply the needs of the district, but at times there is a great scarcity of maize in Keta. It is probable that part of the maize crop grown in the Djoje district is taken across into French Togoland and so reaches Lome market. It is certain that Keta is dependent on Lome for a considerable part of its supply of maize, and, as the Government of French Togoland can stop this supply, as it has done at the moment, when it so desires, a shortage is caused in the Keta market. The second maize crop of 1929 was practically a failure in the Keta-Ada district, owing to drought and locust attacks, and such a scarcity of maize is now being experienced. A 140 lb. bag of maize in Keta at the moment is worth 35/– to 40/–, whereas in normal times it is worth 10/–.

E. THE LIVE-STOCK AND POULTRY INDUSTRIES.

The live-stock areas, the live-stock and poultry industries of the Keta-Ada district, and the needs of these industries are fully dealt with in a report on " The Live-stock of the Coastal Area of the Eastern Province of the Colony," written in 1928 by Captain J. L. Stewart, of the Veterinary Department.

Undoubtedly the primary necessity in improving the cattle, and indeed all classes of live-stock, is the introduction into the district of good sires and the castration of weedy or poor male animals, some of the male animals seen in the district being of very poor class indeed.

A very considerable trade is done with sheep and goats, the trade being almost wholly in the hands of Hausa traders, who travel round the district buying animals which they market in Accra.

Pigs are abundant in the coastal area, and especially so in the Ada district, the trade in pigs being carried on by natives of Ada.

Cassava is fed to pigs, and they are usually in good condition, but almost every pig must be badly infected with *Cysticercus cellu-*

losus, the intermediate stage of *Tænia solium*, a tapeworm of man, owing to the filthy feeding habits of the pig and the insanitary conditions of the villages.

Poultry.

Turkeys and ducks of very good types are found in the district, being most abundant along the coastal belt in the Keta district.

Ordinary fowls are found throughout the district and are of the usual poor type of Gold Coast fowl. By the introduction of English male birds or settings of imported eggs, which could be hatched out in the district, great improvement in the quality and type of fowls could readily be effected. Many poultry owners in the district are desirous of carrying out such improvements.

The live-stock and poultry industries are of considerable importance, and, now that the Veterinary Department has decided to attend to their needs, both are likely to develop rapidly in the near future.

DEVELOPMENT OF THE DISTRICT.

The Keta-Ada district has great possibilities of future development of its agricultural industries, and this is likely to be aided considerably by the construction of the new Dodowa-Ada road, as it will mean much easier access for the produce of the district to a large market centre like Accra.

The industries likely to develop most in the future are the copra and the live-stock and poultry industries, and activities should be concentrated on these.

While the output of copra may not be capable of being increased to any very great extent, it certainly could be increased considerably by the introduction and use of artificial manures, as the non-fruiting of so many palms is undoubtedly due to poverty of the soil. The carrying out of manurial experiments with coconut palms is advisable.

The most urgent need of the copra industry, however, is improvement in quality of the produce. The quality is definitely bad, and the development of the industry must be delayed and hindered until improvements are made. The introduction of buying centres and a system of compulsory inspection before the produce is bought by a merchant, along with instruction to the producer of the proper methods of preparation, are the most effective and thorough ways of bringing this about.

Finally, the keeping of the Keta lagoon permanently flooded, as is the present intention, will also aid in the future development of the district, as the lagoon forms a short and convenient route from the interior and mainland side of the lagoon to Keta.

PAPER No. XVII.

AGRICULTURAL PRODUCE CROSSING VOLTA RIVER AT SENCHI FERRY.

By A. C. MILES.

In August, 1928, it was decided to post a Department Officer at Senchi Ferry for the purpose of recording agricultural produce crossing the river. It was generally known that extensive and increasing supplies of foodstuffs were being sent from the Volta River and Ho districts to places as far west and south as Koforidua and Accra. In the absence of records, there had for years past been wild guesses made concerning the nature and amount of produce in transit at different periods of the year.

For a check to be of real service in a case of this sort carefully detailed records are necessary, and must be scrutinised at frequent intervals to permit of amendments or alterations being made as necessity or occasion arises. Records for the past year are sufficiently comprehensive to afford a fairly good picture, showing nature and kind of produce, time of production, centre or town of origin, weight of produce, and final destination.

Apart from the surprisingly large quantities of raw produce recorded, the most striking feature is the distance between producer and consumer. It is astounding to find that yams grown around Palime are transported 130 miles for sale in Accra, and can be disposed of in the latter place at a profit to producer and retailer. Maize production in Frankadua, 70 miles from Accra, is another instance similar to that above. Neither crop can be regarded as other than essential food, and must therefore be sold at a reasonable and competitive price.

Good road systems in the districts mentioned permit motor-lorry traffic to ply regularly throughout the year. Such lorries are, for the most part, owner-driven, and passenger traffic between villages helps to ensure a full load for the return journey, thus permitting of cheap freight rates. Assuming the low rate of 6d. per ton-mile as the charge for cargo, it is evident that yams from Palime have to bear 65/– per ton transport to Accra.

It would appear to be economically unsound to transport food-crops a minimum distance of 60 miles when there are equally suitable areas sufficiently extensive to produce all the food required

within 25 miles of Accra. That farmers in the Ho district should be able to compete with growers nearer to the Accra market suggests that the former are the more thrifty and content with smaller profits. The question of values no doubt plays an important part in the scheme, since farmers who have not been accustomed to £6 per acre or more from cacao, are satisfied with 25/- per acre from food-crops.

The table on p. 163 shows the total quantities of produce crossing the ferry during the twelve months October, 1928, to September, 1929, the principal centres of origin, and name of places to which the major portion is consigned. The distances between the larger centres of production and consumption are also shown. The cattle and sheep recorded have come south by the cattle route *viâ* Yendi ; the goats and pigs from the villages about Pechi.

Notes Relating to the Products Enumerated.

"*Beans*" are the dried seeds (Pulses) of several common species of Vigna, Cajanus, Phaseolus, etc., used principally in the making of soups. "*Coffee,*" the seeds of *C. liberica*. "*Corn*" (Maize) grain, ground in consuming centre, and cooked in various forms. "*Garri*" is the coarsely ground tubers of dried Cassava, used for cooking purposes, thickening of soups, etc. "*Kokonte,*" the peeled split tubers of Cassava, sun-dried ready for conversion to "Garri." "*Palm Oil*" is a superior quality used for culinary purposes. "*Tiger Nuts,*" the dried tuberous roots of *Cyperus esculentus*, used extensively in the making of gruel, or otherwise parched and eaten dry. "*Yams,*" the mature tubers of *Dioscorea alata*, a staple food, cooked in numerous ways. "*Coco Yams,*" the fresh mature tubers of *Colocasia antiguorum*, when cooked is the staple food of poorer classes. "*Water Yam,*" the mature tubers of *D. colocasiœfolia*, a common food of labouring classes. It is usually sliced and boiled, and being inferior to *D. alata* is always cheaper. "*Calabash,*" the sun-dried shells from mature fruits of *Lagenaria vulgaris*. Selected, medium to large, sizes are used as drinking vessels, containers, bowls, measures, etc.

QUANTITES ARE SHOWN IN TONS EXCEPT WHERE OTHERWISE STATED.

Produce.	Quantity.	Centre of Origin.		Chief Destination.		Miles carried.		
Beans ...	18.1	Ho	12.5	Accra	11.5	Senchi-Ferry	Accra	58
		Palime	2.5	Koforidua	5.5		Koforidua	45
						Palime	Koforidua	117
Cacao ...	1703.1	Pechi	619.4	Accra	1006.3	Palime	Accra	130
		Ho	125.8	Akuse	528.3	,,	Somanya	85
		Tsito	421.1	Somanya	132.6	,,	Akuse	84
		Vegbe	69			,,	Nsawam	124
Coffee ...	7.5	Dsolokpoeta	6.5	Accra	7.5	Palime	Ogoli	72
						Ho	Koforidua	90
Corn ...	683.2	Frankadua	649	Accra	501.8	,,	Accra	103
				Akuse	97.2	,,	Somanya	58
						,,	Akuse	57
Groundnuts	175.1	Ho	115.4	Accra	138.1	,,	Nsawam	97
		Palime	37.7	Koforidua	30.3	,,	Ogoli	45
						Kpandu	Accra	141
Garri ...	74.7	Palime	49.8	Accra	65.3	,,	Koforidua	128
		Kpandu	9.6			,,	Somanya	96
Kokonte ...	84.8	Kpandu	24.3	Accra	39.3	Pechi	Accra	87
		Frankadua	34.9	Koforidua	7.2	,,	Koforidua	74
				Akuse	17.2	,,	Somanya	42
Palm kernels	12	Pechi	6.5	Somanya	4.9	Tsito	Accra	87
				Accra	3.8	,,	Koforidua	74
				Akuse	3.3	,,	Somanya	42
Palm oil ...	52.3	Kpandu	12.3			Frankadua	Accra	67
		Palime	10.3	Accra	46.6	,,	Koforidua	54
		Kpedsu	9.5			,,	Somanya	22
Onions ...	1.1	Anfoe	0.1	Nsawam	0.1	Kpedsu	Accra	113
						,,	Koforidua	100
Oranges ...	32	Pechi Abanasi	11.4			,,	Somanya	68
		Pechi Dzaki	8	Accra	15.6	Dsolokpoeta	Accra	108
		Dsolokpoeta	6	Ogoli	7	,,	Koforidua	95
		Kpandu	5			,,	Somanya	63
Plantains ...	5.7			Accra	3.4	Vegbe	Accra	96
						,,	Koforidua	83
Tiger nuts	11.5	Palime	4	Accra	5.7	,,	Somanya	51
Yams (fine)	786.6	Palime	240.9	Accra	470.2			
		Kpandu	213.5	Koforidua	108.7			
		Ho	112.9	Akuse	61.8			
Coco yams	82.3	Kpedsu	16.9	Akuse	25.7			
		Frankadua	15.1	Accra	33.6			
Water yams	4.9	—	—	—	—			
Capsicum	1.6	Palime	0.9	Accra	1.1			
Calabash ...	26,402 No's	Ho	12,390	Accra	9,430			
		Palime	5,060	Koforidua	5,036			
Cattle ...	3,477 ,,	—		—				
Sheep ...	14,498 ,,	—		—				
Pigs ...	14 ,,	—		—				
Goats ...	11 ,,	—		—				

PAPER No. XVIII.

AGRICULTURAL SURVEY OF WESTERN PROVINCE.

By J. C. MUIR and J. D. BROATCH.

The report deals with agricultural resources of the Ancobra, Aowin and Sefwi districts in the Western Province of the Colony. These districts are developing rapidly, and, in view of the possible construction of a railway from Prestea to Bibiani, information as to the present position of agriculture and the agricultural potentialities of the area was required. (This report appears in Sessional Paper No. X of 1930–31).

THE METHOD EMPLOYED.

A survey was carried out in some detail, every village in the area was visited, and information relating to population, production of crops and general agricultural conditions was collected. Cacao, being the only crop produced in considerable quantities for sale, has received special attention. To obtain figures for present production and future development each farmer was asked to state the number of loads (60 lbs.) he harvested annually and the proportion of non-fruiting to fruiting trees.

MAP SHOWING CACAO PRODUCTION, ETC.

From this data, which is summarised in Appendix I, a map has been prepared. This shows the total tonnage of cacao capable of being produced from existing farms, each lot of 100 tons being presented by a dot and the distribution of the crop shown in colour. Uncoloured areas are, in general, suited to cacao cultivation, but are almost entirely uninhabited. Forest reserves selected, proposed and suggested are also shown.

CHECK ON CENSUS DATA.

While the tonnage of cacao railed from the stations tabulated in Appendix II, plus the quantity transported to Ancobra and *viâ* Tanosu to Half Assini, provides some check upon the total tonnage of cacao, as derived from information supplied by farmers, it is by no means complete, as there is a considerable quantity of cacao grown which may not be marketed owing to difficulties in transporting it.

SURVEY H.Q. ACCRA, 1930.

To obtain some check upon the quantity of cacao derived from the more remote parts, temporary officers were stationed at Diaso for the Dunkwa-Wioso and Dunkwa-Bibiani areas, and at the Ancobra River for the south-west of Ancobra and north of Aowin districts. Checks at these points also served the purpose of determining the quantity of cacao which would provide immediate freight for the proposed Western Province railway. The officers stationed at the points mentioned recorded the tonnage and origin of cacao passing towards the existing Kumasi-Sekondi Railway.

The quantity of cacao which should have been checked at Diaso and Ancobra River was 8,107 and 2,206 tons respectively (2,449 less 243 *viâ* Ancobra and Tano), while the actual quantities recorded were 5,232 tons and 860 tons. The deficits are not so serious as they appear for two reasons. In the first place, season 1929–30 was not a good one, the crop being probably 10% below the average yield, and, in the second place, market values for cacao were such as to preclude speculative buying. On a falling market, prices were too low to pay producers in distant parts to market more of their crop than necessity compelled, as a result of which part only of the crop was reaped. In addition, much of the cacao sold as minor-season crop is in reality major crop, which has been delayed in arriving from the distant outlying parts of western Sefwi.

AGRICULTURAL CONDITIONS WITHIN THE AREA.

Physiography.—The area in general is irregular and steeply undulating, but definite hill ranges occur in western Sefwi. These, and the numerous isolated hill masses which occur throughout, make road construction difficult and costly. Extensive tracts of flat land are absent.

Rainfall.—Using Auchinleck's method (Department of Agriculture Bulletin No. 2) of classifying the climatic zones into groups according to the degree of wetness recorded at each station, the three districts would fall within the upper medium group. The rainfall varies between 70 and 50 inches, being highest in the south and decreasing to nearly 50 inches in the north, where the forest is of a more markedly deciduous type than in the south. Owing to the blanketing effect of the wide belt of forest which intervenes between these districts and the savannah country of Ashanti, the influence of the *harmattan* is not pronounced. The bulk of the forest, according to Chipp (Gold Coast Forest Officers' Handbook), is evergreen, the exception being a portion of northern Sefwi.

Soils.—These vary greatly and irregularly throughout the three districts, the most productive being the deep lateritic red loam of central and eastern Sefwi and northern Ancobra, and the least

productive the shallow quartz gravels of southern Ancobra and Aowin.

CACAO CULTIVATION.

As may be observed from the map, the largest producing centres are found in Sefwi and northern Ancobra. This is due to several factors, of which the influence of the old Agricultural Station at Wioso is an important one—the station having had a widespread effect in disseminating knowledge of methods of establishing cacao. In these parts, too, the most fertile soils exist, and the Sefwi area has had for some time the advantage of road connection with the railway at Dunkwa. From the Agricultural Station as a centre, itinerant instructors demonstrated planting out of cacao farms and preparation of the crop, paying particular attention to spacing and shading. In the early days of the industry, when farmers knew nothing of cacao cultivation, this instruction was well received, with the result that many of the older farms are well laid out. As cultivators became more familiar with the crop, however, they found that farms could be established with less attention than had been given in the past, and many have now taken to over-clearing and close planting (6 to 8 feet apart) in order to reduce weeding to a minimum and to obtain high yields in the early fruiting years. The condition of the older farms varies considerably, over-cleared and closely planted farms, and farms on unsuitable sites, decreasing in yield at an early age. "Akate" (*Sahlbergella*) damage is fairly common throughout the three districts, but appears to be less acute than in Ashanti, probably owing to the fact that the *harmattan* is not so severe as in the latter place. Considerable areas of young cacao are being planted at present, the proportion of non-fruiting to fruiting trees being 1.5 to 1. Unfortunately, less care is being paid to spacing and shade than was formerly the case. This retrogression in farming methods is serious in view of the ever-increasing acreage of young cacao and the danger to which this is exposed by excessive deforestation. The farmers in the Western Province have not had a lengthy enough experience of cacao growing to understand the beneficial effects of shade, nor do they appreciate that in its absence a certain amount of tillage is required.

NECESSITY FOR FOREST RESERVES.

In view of this, Forest Reserves are more necessary now than ever, for the safeguarding of existing cacao by maintaining atmospheric humidity. Deforestation in the neighbourhood of Prestea has had a severe effect on the few existing farms, and has rendered virtually impossible the establishment of new cacao farms for miles beyond the town.

The total area of the reserves now established is 407 square miles, while proposed reserves have an aggregate area of 145 square miles.

HARVESTING AND PREPARATION OF CACAO.

Methods of preparation leave much to be desired, but it will be impossible to persuade the farmers to be more painstaking until there is a distinction in price between good and bad quality. The large percentage of germinated and black beans in some samples is due to the fact that farmers are content to harvest the crop in from one to two pickings, and while waiting for a large percentage of pods to ripen the contents of the earlier ones deteriorate through germination. Again, in villages remote from the motor road, where even head transport is difficult to obtain, prepared cacao is stored under unsuitable conditions for long periods, allowing moulds and weevils to spoil a further percentage.

The development of roads will do much to rectify this, as farmers will be able to sell in their villages and will therefore be encouraged to pick more frequently and to sell immediately. Although a small minor season crop of cacao is produced in these districts, with the exception of northern Sefwi, it is generally allowed to remain on the trees on account of heavy rainfall at the time of ripening and inability to dry the beans. The cacao sold as minor season crop is almost invariably the previous crop which has come in from distant villages after the close of the major crop season.

It seems probable that in the younger cacao areas some benefit would still result from instruction and demonstration in the laying out of cacao farms. With regard to preparation of the product, little immediate improvement is likely to follow upon purely advisory work, but from co-operative societies or from a system of certification improvement in quality is certain to result.

CACAO YIELDS PER ACRE.

By making pod counts on numerous cacao farms, and calculating these on a basis of 13 pods to the pound of cured cacao, the mean yield throughout the three districts on native farms proves to be approximately 6 cwts. per acre, but that yield reaches a figure twice as high on some farms is the considered opinion of the writers.

ACREAGE UNDER CACAO CULTIVATION.

At this figure the acreage under cacao represented by the 10,958 tons of beans despatched from the stations shown in Appendix II would be 36,527, while the acreage under non-fruiting cacao would be 54,801, making a total of 91,328 acres. As the non-fruiting farms come into bearing there should be a gradual increase in the production of these districts to about 25,000 tons in five to six years' time.

There is, however, a possibility which cannot be overlooked: the cacao farmers of this country have for some years been obtain-

ing good prices for the product of their farms, and they have not yet been tested by adversity. In the area with which this report deals, the farmer grows his food crops in addition to cacao, and the revenue gained from the sale of his cacao crop is used to buy luxuries. The price of cacao has now dropped to a level above which it appears unlikely to rise at least for a long time, and it may be that farmers in new cacao areas such as this will consider themselves so inadequately recompensed for their work that they will not take the trouble to attend to the young farms, their existing fruiting farms being capable of supplying the articles demanded by their standard of living.

COFFEE DEVELOPMENT AND PREPARATION.

This crop has received considerable attention during the past few years, especially in Sefwi. The number of fruiting trees is as yet small, but a conservative estimate of the area planted out, or capable of being planted from existing nurseries, is 6,000 acres. The recent interest is probably due to depreciation in the price of cacao and a false idea as to the value of coffee. Seeds have been obtained from existing farms, from the Agricultural Station at Wioso, and from the French Ivory Coast, at a price of approximately 4/– per lb. The industry is not yet definitely established, and a rise in the price of cacao consequent upon extension of roads might lead to its abandonment.

There are several unsatisfactory features in the development of this industry. Farmers are ignorant of planting and cultural methods. Farms are being badly laid out, the trees allowed to grow to such a height that picking will be extremely difficult. In addition to this, farmers, knowing nothing of varieties, accept seeds of any type, with the result that Liberica, Robusta and Stenophylla are being planted indiscriminately. It is apparent that if a sound industry is to be established, and a standard product put upon the market, one variety would require to be grown exclusively. If it is decided that the growing of the crop should be encouraged, benefit would accrue from the demonstration of planting and cultural methods to farmers.

As regards preparation of the product, valuable assistance would be rendered by the setting up of central depericarping plants. Whether this were done by Government, by private enterprise, or by a co-operative system, it would be more easily and cheaply worked if all berries brought in were of the same variety.

COMPARATIVE VALUE OF CACAO AND COFFEE.

West African coffee is at present worth 32/– per cwt. f.o.b. for cleaned beans ready for the European market, whereas cacao is

worth 34/– per cwt. f.o.b. The differences in yields per acre are not in favour of coffee, and it is difficult to see how it can ever compete successfully with cacao. Comparative values per acre, based on the above quoted prices, are as follows: Average yields per acre of Coffee Liberica recorded at Wioso Station were $3\frac{1}{2}$ loads per annum. Current value 8/– per load at Dunkwa, $3\frac{1}{2} \times 8$ — £1 8s. per acre. Estimated mean yields per acre for cacao, 11 loads per annum. Current value at Dunkwa 9/– per load; 11×9 — £4 19s. per acre. Another factor which will mitigate against success is the difficulty of picking coffee owing to the presence of the red tree ants, which swarm on every bush. At a European-owned plantation in the vicinity, where a small plot of coffee is cultivated, it is found necessary to pay a premium of 3d. per day for labourers engaged in plucking the crop.

OTHER CROPS, LIVE-STOCK, ETC.

Cola trees occur sporadically throughout these districts, but receive little attention. A small local demand is supplied and a few loads railed annually. In view of the falling off in demand for Gold Coast cola from Lagos, no expansion of this industry can be anticipated unless new markets are found, as Ashanti is capable of supplying the overland demand.

Coconuts.—In most villages in southern Ancobra and Aowin a few flourishing coconut palms are to be seen on well-drained sites. Their healthiness and appearance of giving good yields indicates that plantations might be successfully established. The heavy rain fall of the area would necessitate the use of artificial driers for the preparation of copra.

Food Crops.—Plantains, coco yams and corn are the staple food crops of the people and are grown in every village. In southern Aowin a distinctive decrease of coco yams is becoming common, and it appears probable that rice, which is already grown there, will become a more important food crop. In Sefwi yams are commonly grown, but in southern Ancobra and Aowin there is reported to be difficulty in growing them successfully. This may be due to the heavy rainfall, which makes waterlogging and flooding of the soil a frequent occurrence during the wet season, but the matter is one which requires further investigation.

Oil Palms occur in considerable numbers in secondary forests, and the oil is prepared to a limited extent for local use at prices above the export value. Palm wine is being made in increasing quantities, and is a profitable industry to the producers. Kernels are not utilised, and although one firm in Dunkwa offered a reasonable price per load, none were brought in.

Live-stock.—Practically no cattle exist in the area surveyed, but most villages possess a few sheep and goats which are slaughtered

for religious purposes. They do not enter largely into the diet of the people. Fowls are not numerous; types are poor and prices high. The only industry in live products which is carried on with any degree of system is snail collecting, which is controlled by strictly enforced native bye-laws. This industry has been described by Martinson (Department of Agriculture Year-Book, 1928).

DEVELOPMENT DEPENDENT ON ROAD SYSTEM.

Agricultural development will be greatly accelerated by the construction of Insu-Enchi and Wioso-Krokosua roads. At present cacao has to be head-loaded distances up to 80 miles at a cost of 5/– to 10/– per ton-mile, as against 1/– per ton-mile for motor transport. With the completion of these two main roads, and the construction of a few feeder roads tapping the chief producing areas, the districts will be reasonably well served.

To obtain the full benefit, however, the two main roads should be linked up to enable merchants who have established headquarters in Dunkwa to reach areas tapped by the southern road with the minimum of delay. During the cacao season 1929–30 the price of cacao on the Insu-Enchi road was invariably lower than it need have been owing to lack of competition among buyers, which was directly due to the delay entailed by the absence of road connection with Dunkwa. This connection could be easily made from Aropong to Nkunsia.

CONCLUSIONS.

While the total census of production-figures for the three districts differ from the quantity of cacao recorded leaving the districts by 19.3% of the former, it must be borne in mind that season 1929–30 in these districts was a poor one. At the same time the crop distribution, as obtained by the census method and by check, showed a greater discrepancy than could be accounted for by the factors previously discussed. It would appear that this was due to deliberate misrepresentation on the part of those people who inhabit the area which would have been tapped by the Western Province Railway; in their efforts to secure for themselves the benefits of improved communications, either by road or rail. Before any information of a statistical nature could be obtained considerable opposition from the people had to be overcome, and it is evident that this will be the case for a long time to come unless the officers in charge of field work are known personally to the people.

APPENDIX I.

Census of Population and Production per 1,000.

District.	No. of Villages.	No. of Compounds.	Population.			Prod. per 1,000 of Population.
			Male.	Female.	Total.	
Sefwi ..	302	5,157	19,760	17,265	37,025	199 tons
*Ancobra ..	293	4,466	15,629	12,734	28,363	182 ,,
Aowin ..	48	829	4,291	3,317	7,608	137 ,,

N.B.—In each district the ratio of young to fruiting cacao trees is 1.5 to 1.

Census of Farmers and Estimated Production.

District.	Farmers with Fruiting Farms.			Farmers with Young Farms.			Estim. Prod. of Cacao.	Prod. per Farmer with Bearing Farm.
	Male.	Fem.	Total.	Male.	Fem.	Total.		
Sefwi ..	6,454	2,284	8,738	8,677	4,449	13,126	7,379	16.9 cwt.
*Ancobra	4,707	720	5,577	5,961	1,404	7,365	5,142	18.4 ,,
Aowin	1,273	423	1,696	1,772	2,737	2,509	1,044	12.3 ,,

* Census figures do not include Dunkwa, nor villages east of the railway.

APPENDIX II.

Despatches from Province during April, 1929, to March, 1930.

Consignments from Stations.	*Tons of Cacao.*
Dunkwa	9,027
Buabin	127
Imbraim	22
Oponsu	137
Opon Valley	311
Insu	1,091
Consignments by River.	
Viâ Ancobra / ,, Tanosu	243
Total	10,958 tons.

PAPER No. XIX.

ECONOMIC PRODUCTS AND INSPECTION IN KETA-ADA DISTRICT (including system of Produce Inspection in Force in French Togoland).

By J. T. H. STEIN.

The only economic products of importance or value in the Keta-Ada district are coconuts, copra, palm kernels and palm oil.

COCONUTS.

Coconut palms are found growing in an almost continuous belt from the Volta River to Aflao, a distance of 49 miles along the narrow sandy coastal strip lying between the sea and the lagoon, while on the mainland side of the lagoon a very large area of coconut palms is found between Agbosome and the lagoon and around Aferingba.

From Atiteti and Ada district considerable numbers of coconuts are shipped up river and sold in Akuse and Accra. This is done in preference to preparing copra, as it is more profitable.

COPRA.

The copra produced in the district is undoubtedly of very poor quality and fetches a corresponding poor price on the home market. The main defects are entirely due to faulty and careless methods of preparation, and can all be remedied if the producers will only exercise a little more care and give a little more time to the preparation of their copra.

Defects are as follows :—

(*a*) *Mouldy Copra.*—Moulds are caused by faulty methods of drying, and mainly by insufficient drying. In many cases during preparation copra is left spread out and uncovered at night, with the result that it becomes damp with the dew, and this naturally is not conducive to production of good quality copra.

(*b*) *Soft and Discoloured Pieces.*—This is due to plucking and utilisation of immature nuts.

(*c*) *Sand and Dirt.*—Copra covered with sand and dirt is all too common and due entirely to carelessness on the producers' part.

(*d*) *Small Fragments.*—While this is not a serious defect, it certainly spoils the look of a sample. It is due to immediate removal

of the kernel when the nut is halved, no period being allowed for drying and shrinking of the kernel from the shell.

Possible Methods of Improvement.

Copra production is entirely in the hands of the peasant farmer, who, in many cases, is ignorant of the proper methods which should be used in the preparation of good quality produce, and one of the first steps which should be taken in improving the quality is to carry out intensive propaganda work among the farmers, instructing them in the proper preparation methods.

It can be said at once that the introduction of artificial drying is out of the question, as it is quite impossible to get the necessary firewood in the district, and practically all the coconut husks, which could ordinarily be utilised, are required for domestic fuel. Sun-drying is therefore the only possible method of preparation of copra in the Keta-Ada district. In such a district, where the rainfall is low, the mean annual fall being less than 30 inches, sun-drying is a perfectly suitable method. In sun-drying the main essential is to ensure that, once drying has commenced, the kernel does not again get even slightly wet, since if it does the copra produced will mould. The probable reason for so much of the copra produced in the Keta-Ada district being mouldy is lack of protection from the dew during preparation. To overcome this difficulty, rack or sliding-tray driers might be introduced. The use of these would also ensure the copra being kept clean.

In conjunction with instruction of the farmers, the introduction of a system of produce inspection would greatly aid in improving the quality. This is discussed later.

Possible Future Extension of Copra Industry.

It would appear unlikely that the copra industry in the Keta-Ada district is capable of being increased to any very great extent, or that the average exported tonnage per annum will rise very much over 2,500 tons, the average annual tonnage exported at the moment being about 1,400 tons.

The future extension of the industry depends on the area remaining which is available and suitable for planting coconut palms. Along the coastal belt there is still a little ground available for planting. The chief hope of extension in this part, however, appears to be in the fact that there are so many barren trees which could be made bearing trees if the soil was enriched by the application of artificial manure. In the Agbosome-Aferingba district the industry is capable of further extension, many young palms being seen in that part. The land round Atiave on the north-west side of the lagoon is suitable for coconuts, and a certain amount of copra is brought from there and sold in Keta. In Ada and round Atiteti the coconut grower finds it more profitable to transport fresh

coconuts to Akuse and to sell them there and in Accra than to prepare copra.

It is estimated that the people themselves use three-eighths of the copra manufactured for production of oil for their own purposes.

PALM KERNELS.

The oil-palm products are exported entirely from Denu, the centre of the oil-palm growing area being Djoje, which is 16 miles by road north of the port.

The tonnage of kernels shipped from Denu does not represent the true output of the district, for a large quantity of the kernels produced around Djoje, and in the district lying between that place and French Togoland, are taken across the border to Noepe, sold there and transported by railway to Lome, where they swell the export of kernels from French Togoland. Noepe, which is 4 miles from Djoje, is one of the French produce inspection posts. The buyer in Noepe can always afford to give a rather better price than the buyer in Djoje, for not only is he certain that he is buying good quality produce, but also transport from Noepe to Lome is cheaper than transport by road from Djoje to Denu.

The price paid for kernels at Djoje is £12 per ton, and for palm oil 7/– for 5 gallons, which is approximately £15 15s. per ton. Transport from Djoje costs 15/– per ton.

Defects of Kernels.

The main defect is the large amount of shell and dirt which is to be found among the kernels, the percentage in some cases being high. This is a defect difficult to get rid of, but the inspection methods used in French Togoland have been very successful in lessening the percentage.

EXPORT OF ECONOMIC PRODUCTS FROM THE DISTRICT.

Copra is shipped from both Keta and Denu, while the oil-palm products are exported only from Denu.

Exports of these products from the ports for the last three years are given in Table I and Table II.

INSPECTION OF PRODUCE.

It is the aim of the Department of Agriculture to improve the quality of produce by effecting a system of inspection or grading. So far no produce inspection has been carried out in the district, except in the case of oil-palm products, where the trading firms employ an inspector, but it is hoped a start will be made, especially with copra, early in 1930. No thoroughly satisfactory system has as

yet been devised, and it is the purpose of this report to suggest one. The method suggested by J. L. Scott, in his article on "Trials of Certain Methods of Sampling Copra," in the 1928 Year-Book, a method similar to that used in port inspection of cacao, while quite suitable for that product, presents many difficulties when applied to produce like copra.

The method or system hereafter explained, used by the Produce Inspectorate in French Togoland, would appear most satisfactory. This method is similar to that used in Nigeria.

SYSTEM OF PRODUCE INSPECTION IN FORCE IN FRENCH TOGOLAND.

All information on this subject was kindly supplied by Mr. Robert, the European inspector in charge of the Produce Inspectorate of French Togoland. Mr. Robert has been in charge since December, 1924, and has built up a very thorough and complete organisation, which is borne out by the excellent results and quality of produce obtained.

In French Togoland there is compulsory inspection. Ordinances are in force which prohibit the purchase or export of any produce unless it has been inspected and passed by an officer of the Produce Inspectorate as being up to the required standard.

In December, 1924, only two kinds of produce were inspected, viz., cotton and palm kernels. In December, 1926, the field of operation was extended so as to include cacao, coffee, copra and palm oil. Kapok and maize are now also inspected.

Standards of Quality.

A strict standard of quality has been laid down for each kind of produce, and if the inspected sample does not conform with this the produce is rejected and the producer is left with it on his hands.

In the case of copra, palm kernels and palm oil the standards are as follows :—

Copra.—Copra must be clean and dry and must not contain more than 2% of sand or foreign matter. It must not smell smoky or show any trace of internal mould.

Palm Kernels.—Kernels must be clean and dry and must not contain more than 4% of shell or other foreign matter, and must not have undergone any operation which will have lessened the oil content.

Palm Oil.—Palm oil must not have a rancid smell and must not contain more than 2% of water or impurities. Its colour should be pale yellow to brick red, not blackish.

Organisation of the Service.

The whole organisation is under the control of one European Chief Inspector, whose headquarters are at Lome. The territory under his control is divided into districts, *e.g.*, Lome district, Anecho district, Atakpame district, etc., each of which is supervised by a native Senior Inspector. These districts have a number of inspection posts at suitable centres, and have markets, the dates and days of which are definitely fixed. At each inspection post there is a native inspector, who may carry out inspection at more than one market, where these are so arranged as to be on different days of the week.

Inspectors.

Inspectors are paid by the Chamber of Commerce and are under its immediate direction. In the districts the native inspectors are under the control of the District Officers or Commissioners.

The inspectors have considerable powers, having the right of entrance to all places for the purpose of inspecting produce, and have the power of taking action against anyone who does not obey the ordinances in force. Such actions are reported by the native inspectors to the Chief Inspector at Lome, who, in the case of an action against a native, sees that it comes before the Commissioner of the district concerned and before a higher court where the action is against a European.

The duties of inspectors are to pass produce which is up to the required standard, to order the immediate picking over of produce which shows a percentage of impurities greater than is allowed, to seize the excess of these impurities, to forbid the sale and movement of damaged produce, and to confiscate produce which has been adulterated in any way.

Inspection.

All produce is inspected before it is bought by a trader or his agent, inspection taking place either in the market-place or on the premises of the trading firms.

When the produce is passed by the inspector and bought by a merchant, an inspection ticket, on which is written the kind, the net weight of the produce bought, the percentage of defects, the name of the buyer, the market, the date and the inspector's signature, is given to the buyer.

Reports on the amount and kind of produce inspected, passed and bought by each firm are sent in monthly from the districts to the Director of Service at Lome.

Before a firm can move the produce it has bought from the buying centre to the sea port it must call in the produce inspector and receive a transport ticket. This is similar to the inspection ticket, except that the word "TRANSPORT" is printed across it.

The inspector does not issue a transport ticket until he has collected the inspection tickets and verified the tonnage on these with the tonnage to be railed or moved. The inspection tickets are retained by him. In this case also monthly reports of the tonnage of the various kinds of produce sent by the different firms to the ports are sent from each inspection centre to Lome.

Before exporting at Lome and Anecho a second inspection is made. After inspection and adjustment, if necessary, the transport tickets which accompanied the consignment from the up-country buying centres are retained by the inspector and an export ticket issued which shows that the second inspection has been made and that the produce answers the required conditions.

At the end of each month the European inspector checks his returns with those of the Customs—that is, he checks up the inspection and transport tickets with the export returns of the Customs for the various kinds of produce.

INSPECTION SYSTEM FOR KETA-ADA DISTRICT.

Compulsory inspection on similar lines to the system in force in French Togoland is necessary in the Keta-Ada district if the quality of produce, and copra especially, is to be improved. This may seem drastic, but in this case the disease has reached a crisis, and a drastic remedy must be applied if a cure is to be effected. As long as traders are allowed to buy inferior produce, and as long as some producers are satisfied with low prices, and, finally, as long as copra rejected by inspectors in French Togoland is brought across to Denu and sold there, there is no hope of improving the quality.

Lome copra is infinitely better, and Keta copra cannot be compared with it. This is borne out by the difference in price.

Prices at the moment are :—

Lome	£17 10s.	per ton.
Denu	£15	,,
Keta	£14 4s.	,,

The producers who do produce good quality copra get no encouragement, as their copra is bulked with that of poor quality and receives the low quality price. Wheresoever possible good copra is taken to Lome and sold there.

The proper time for inspection appears to be before buying takes place. There certainly appears to be no point in inspection at the moment of shipping and issuing a certificate to the exporter stating the consignment to be 100% defective ; he is probably quite cognisant of that fact, and, in any case, he cannot be prevented from shipping the produce, which, on arrival home, further damages the

already bad reputation that Keta copra has earned for itself on the home market.

Another point in favour of inspection before buying is that a much more thorough inspection can be made than in the case of port inspection, where only a certain number of bags are examined.

The copra-producing area of the Keta-Ada district is practically confined to the coastal belt and the Agbosome district—that is, the producing area is fairly compact and has the very great advantage of being near the export centres Keta and Denu. It would be comparatively easy, therefore, to effect a system of produce inspection in the district similar to the French Togoland system. Four buying and inspection centres only would be required, the most convenient places for these being Awunaga, Keta, Denu and Agbosome. An inspector would be required in each of these places, being supervised from Keta. If kernels and palm oil were included in the inspection, a very suitable inspection centre for these products would be Djoje. Inspection tickets would be issued at these centres, and before exportation at Keta and Denu the tonnage to be shipped would be checked with these tickets and export tickets issued as in the case of the French Togoland system.

Probably the chief argument against compulsory inspection is that, to begin with, the merchant finds the amount of produce he is able to buy limited, and that through no fault of his own, all the defects of copra being remediable by the producer. But if all the defects of copra are remediable by the producer this is a further argument for inspection before buying takes place and rejection of inferior produce. It is certain, however, that if the producer finds he cannot sell his copra owing to its inferior quality, and that he is left with it on his hands, he will very soon produce copra of better and saleable quality.

One point which the producer must thoroughly understand is that for a period after he improves the quality he will not receive any better price and that the price cannot rise until the produce has gained for itself a better reputation on the home market.

At the moment in the district there is no competition among traders, and there can be none till the quality of produce is greatly improved, and the quickest and most thorough way to improve it is by introducing a system of compulsory produce inspection.

Such a scheme as is suggested above has the great advantage that it is desired by, and has the support of, the merchants, the Fia, and the Chiefs of the district.

TABLE I.

Quarters.	1927			1928			1929		
	Copra, tons.			Copra, tons.			Copra, tons.		
	Keta.	Denu.	Total.	Keta.	Denu.	Total.	Keta.	Denu.	Total.
1	330.84	180.12	510.96	213.06	209.94	423.00	191.18	74.84	266.02
2	184.46	116.48	300.94	226.35	201.35	427.70	153.46	215.61	369.07
3	309.32	149.25	458.57	70.50	48.00	118.50	106.34	46.13	152.47
4	53.51	121.83	175.34	280.39	242.81	523.20	306.80	63.00	369.80
Total	878.13	567.68	1445.81	790.30	702.10	1492.40	757.78	399.58	1157.36

TABLE II.

Quarters.	1927		1928		1929	
	Tons. Palm Kernels.	Tons. Palm Oil.	Tons. Palm Kernels.	Tons. Palm Oil.	Tons. Palm Kernels.	Tons. Palm Oil.
1	53.80	26.89	87.15	—	21.16	—
2	229.35	207.15	83.21	25.86	152.02	56.93
3	166.19	—	22.28	—	141.85	—
4	72.53	—	104.68	11.03	145.22	32.60
Total ...	521.87	234.04	297.32	36.89	460.25	89.53

PAPER No. XX.

ROTATION TRIAL AT EJURA.

SUMMARISED BY H. B. WATERS.

The land on which this trial was carried out is situated near Ejura, in the open savannah country just outside the forest zone. The area is subjected to rather severe *harmattan*. The growing of food crops to supply Kumasi town and its surrounding cacao areas is the principal work of the community, and, as a result of increasing transport facilities, this area has developed considerably during recent years.

The system of farming in general practice in the surrounding country consists in cultivating the land for a period of two or three years and then allowing the land to lie fallow for at least four or five years. The farmer usually grows two crops a year and interplants with catch crops when possible. The main crops grown are yams, maize and groundnuts; other local crops, often grown as catch crops, are rice, pulses and various small food crops.

DESCRIPTION OF THE TRIAL.

The rotation trial at Ejura was laid down by Mr. T. Hunter with the object of studying the effect of continuous cultivation in comparison with a crop rotation having fallow periods every alternate year. The cropping is shown in the following table :—

Plot No.	A 1	A 2	B 1	B 2	C 1	C 2
Year.						
1924	Groundnut	Groundnut	Yam	(Fallow)	Cereal	Cereal
1925	Yam	(Fallow)*	Cereal	Cereal	Groundnut	(Fallow)
1926	Cereal	Cereal	Groundnut	(Fallow)	Yam	Yam
1927	Groundnut	(Fallow)	Yam	Yam	Cereal	(Fallow)
1928	Yam	Yam	Cereal	(Fallow)	Groundnut	Groundnut
1929	Cereal	(Fallow)	Groundnut	Groundnut	Yam	(Fallow)

For continuous cultivation (plots A1, B1 and C1) there is a three-year rotation—groundnut, yam, cereal; for alternate fallowing (plots A2, B2 and C2) the sequence of crops is groundnut, cereal, yam in a period of six years.

* During the fallow periods (plots A2, B2 and C2) cover-crops, usually *Mucuna* sp., were grown on the land.

EXPERIMENTAL RESULTS.

The full results of yields are given in Table No. 1 below :—

TABLE No. 1.

YIELDS IN LBS. PER ACRE.

Plot No.	A1 Continuous.	A2 Fallow.	B1 Continuous.	B2 Fallow.	C1 Continuous.	C2 Fallow.
Year.	Crop. Yield.	Crop. Yield.	Crop. Yield.	Crop. Yield.	Crop. Yield.	Crop. Yield.
1924	G'nuts 1,024	G'nuts 757	Yams 7,952	Cover crop Nil	Maize 224 Rice 738	Maize 223 Rice 691
1925	Yams 8,647	Cover crop Nil	Maize 2,534 Rice 620	Maize 2,352 Rice 503	G'nuts 604	Nil Nil
1926	Maize 1,443	Maize 1,579	G'nuts 780	Cover crop 672	Yams 8,040	Yams 6,138
1927	G'nuts 1,022	Cover crop Nil	Yams 9,679	Yams 11,778	Maize 1,299 Rice 309	Cover crop Nil
1928	Yams 13,468	Yams 12,714	Maize 1,366 Rice 339	Cover crop Nil	G'nuts 1,676	G'nuts 1,539
1929	Maize 964	Cover crop Nil	G'nuts 1,391	G'nuts 909	Yams 12,194	Cover crop Nil

In Table No. 1 the pairs of plots which have been *underlined* are the cases in which comparisons are possible between the "continuous" and the "fallow" rotations. There are eight cases altogether, and out of these there are six cases in which the yields of the "continuous" plots are greater than the yields of the "fallow" plots, despite the fact that the cropping is twice as heavy on the "continuous" plots. Observation on the field has shown that lalang (*Imperata* sp.) has increased on the "fallow" plots and that the cover crops planted during the fallow periods have not kept the lalang in check. It is clear, therefore, that, from every point of view, the system followed in plots A2, B2 and C2 has been unsatisfactory. The intensity of cropping has been too light (three crops in six years) as compared with the cropping on local farms, the management of cover crops in alternate year fallows has not kept lalang under control, and the yields have been lower than those of a rotation with a much heavier cropping intensity.

Comparisons can also be made between rotational cycles on each plot. Thus in plot A1 groundnuts yielded 1,024 lbs. per acre in the year 1924, and in the second rotational cycle yielded 1,022 lbs. per acre in 1927 ; yams in plot A1 in 1925 and 1928, and maize in 1926 and 1929, may similarly be compared. Such comparisons are difficult on account of seasonal variations, as 1925 may have been a bad year for yams and 1928 may have been a good year for them ; criteria are necessary and are obtainable by comparing the yield of each crop in any one year with the average yield of the same crop in neighbouring farms, but this information is not available. Com-

paring the yields in plots A1, B1 and C1 for the years 1924–26 with the yields for the same crops in the same plots for 1927–29, it will be found that out of eleven pairs of comparisons the yields for 1927–29 were higher in six cases. Thus continuous cropping has not led to reduced yields. The cropping, however, has not been intense, viz., one crop annually, or four crops in three years, compared with the local farmer's method of at least two crops annually with additional catch crops when possible.

MEAN YIELDS.

The results are mainly of interest purely as yield figures. These are shown in the following table :—

TABLE No. 2.

Crop.	No. of Records of Plots.	Yield of plots, 1924–29 (lbs. per acre).			
		Highest.	Mean.	Lowest.	Produce.
Groundnuts	9	1,676	**1,078**	604	Dry unshelled nuts
Yams ..	9	13,468	**10,057** (=**4½** tons)	6,138	Fresh tubers
Maize ..	9	2,534	**1,332**	223	Dry grain
Rice ..	6	738	**533**	309	Dry paddy

These are fair yields and require no special comment. Farmers and the Department agree that the crops grown on this rotation have been larger than those grown on neighbouring farms.

LALANG.

Mention has already been made that lalang became out of control in the "fallow" plots of the rotation. The problem of lalang suppression has also been studied at Ejura in a number of small trials, and efforts have been concentrated on testing various kinds of green manures for this purpose and on their management in the farm. Observation has shown that in order to be effective the green manure or cover crop must be capable of persisting in a green state throughout the dry season. If the cover crop dies during the *harmattan*, which (as already stated) is often severe at Ejura, the lalang asserts itself before the ground can be cultivated in preparation for the ensuing crop.

Trials have been made with *Crotolaria striata*, *Cajanus indicus*, *Centrosema plumieri*, *Calopogonium mucunoides*, *Indigofera* sp. and *Mucuna* sp. Of these, *Crotolaria striata* maintained the best cover during the dry season, and the plots in which it was grown showed the least tendency to revert to lalang. An excellent photograph,

depicting *Crotolaria striata* at its best, is seen in the Departmental Year-Book, 1928, p. 249; the dense canopy made by this plant is clearly shown. It is possible that *Crotolaria striata* could be incorporated into the system of arable farming followed locally with beneficial effect, especially for the purpose of controlling the spread, or possibly even for the suppression, of lalang.

CONCLUSION.

This rotation has served its purpose and has now been discontinued. Several interesting conclusions, mainly of a practical nature and in connection with lalang, have been brought to light during its continuance. It has clearly shown that the problem of shifting cultivation is not soluble by one trial of this description, but requires the laying down of a comprehensive series of experiments planned in every detail. Such a series would cost a considerable sum in upkeep, and it is a matter for serious consideration as to whether this would be justified.

SUMMARY.

(1) A rotation trial of food crops, carried out at Ejura for the six years 1924–29, is described and the results given.

(2) The system of cover crop fallows in alternate years was not a success.

(3) In a rotation of light intensity the cropping in the second rotational cycle (of three years) was as heavy as in the first cycle.

(4) For the suppression of lalang, *Crotolaria striata* was found to be the best of the cover crops tried, as it maintained a good cover throughout the dry season.

(5) A solution to the problem of "shifting *versus* continuous cultivation" would require a comprehensive series of well-planned experiments.

PAPER No. XXI.

A NOTE ON MIXED CROPPING IN THE YAM-GROWING DISTRICTS OF THE NORTHERN TERRITORIES.

By G. COWAN.

In the yam-growing districts, and, in particular, the area round Tamale where the observations are made, the practice of mixed cropping is almost entirely universal. Definite combinations of crops grown in the same year have been evolved to suit the particular types of soil, and, in the ordinary course of events, are fairly strictly adhered to. Sesame (*Sesamum indicum*), "bungu" (*Ceratotheca Sesamoides*) and tobacco are, however, almost invariably grown alone, and are notable exceptions to the general rule. In addition, rotational systems of yearly cropping are followed.

While the crops are not "mixed" in the sense of being either (*a*) planted in a haphazard fashion, or (*b*) at the same time, or (*c*) all complementary without one crop being dominant, yet they are neither "catch" nor "successive" in the sense that one crop is harvested before another can be planted. The native practice is virtually an elaboration of the two methods, and consists of planting certain crops at definite successive intervals of time, in accordance with their optimum planting times and only partly in accordance with the length of the growing period of each particular crop. It thus happens that the crops are not necessarily harvested in the rotation in which they were planted.

In some cases true haphazard mixtures of many and varied crops are met with. These are usually found only in the more intensively cultivated farms near the villages. Also in every case the main crop, which is commonly yam, is always given the most attention. The subsidiary crops are benefited by the cultivations for the main crop and *vice versâ*, very little extra work is required in planting the seeds on the yam mounds, and usually the routine cultivations given by a good farmer to the prior crop suffices for the subsidiary crops. As an example of the large diversity of crops growing together on the same farm the following may be cited. On one particular farm, of less than 1 acre in extent, yams, rice, okro, pigeon pea, cassava, water yam, a native bean and maize were observed. The first two were obviously the main crops, and the remainder were

planted on the sides of the yam mounds without much attempt at a system. While these extremely diversified mixtures of crops are only found in combination with yams in the more intensively cultivated farms, yet mixtures of two or three of the important crops are commonly met with at a stage in the rotation when yams are not included.

EXAMPLES OF MIXED CROPPING.

The cultivation of the main crops of foodstuffs is naturally the most important object, and it might not be out of place to state at this point a few of the common systems of mixed cropping. These may be classified according to their suitability for certain types of soil.

A. On heavy low-lying soil which tends to become saturated at the height of the rains :—

(1) Yam (early crop), early maize on mounds.

Rice planted between mounds. In addition, further lines of late rice planted on the early yam ground when harvesting is completed.

(2) Medium early maize and guinea corn.

B. On soil similar to A, but not so low lying :—

(1) Yam (main crop), early maize on sides of mounds.

Rice planted between mounds.

(Cotton planted on sides of mounds after maize has been harvested.)

(2) Maize and guinea corn.

C. On medium sandy soils :—

(1) Yam, okro and cowpea on mounds.

Millet between mounds.

(2) Maize.

Groundnuts.

Guinea corn.

D. On very sandy soils :—

(1) Yams (large mounds).

Millet between mounds.

(2) Groundnuts and millet.

(3) Millet and Bambarra beans.

E. On gravelly soils (late plantings).

(1) Millet and Bambarra beans.

(2) Transplanted millet and Bambarra beans.

When soils under tropical conditions are sparsely covered with vegetation or kept bare, it is generally accepted that they deteriorate very rapidly. (The losses from erosion become excessive during the rains, and if the topography of the land is sloping deposits of barren sand are spread over the lower areas. The resultant loss in fertility can, therefore, be very marked.) By allowing the bush to grow up, or by planting a crop, these deteriorative processes can be stopped to a certain extent, but since the farmer cannot economically cultivate all of his land at the same time there are obvious difficulties in establishing crops. In addition, as the season advances, the bush becomes progressively more difficult to eradicate. Now, if it were possible to cultivate a small area of ground for an early crop and to use the same land for the later crop, it is to be expected that a three-fold gain would result :—

(1) The combined yield of the two crops should, in weight and bulk, be greater than the yield of either of the single crops.

(2) If it is accepted that the most economic method of crop production is to " bush " fallow the land after a number of cropping years (which is by no means proved), then the farmer is enabled to concentrate on a proportion of his ground and give it his undivided attention, while the remainder is under fallow. The same would hold good if, instead of bush fallowing, green manuring was adopted.

(3) The cultivation work would be almost halved, since, for example, one ridging suffices for both crops, hoeings and weedings benefit both, while the increased number of roots and root hairs present in the soil bind the particles more thoroughly and diminish loss by erosion.

NATURE OF THE TRIAL.

The mutual effect of a combination of crops growing together was not known. It was to be expected that the natural result of the admixture (as compared to single cropping) would be a general diminution of yield—not of total produce, but of the individual crops. Therefore, in order to

(1) Measure the differential response of crops to two systems of husbandry (*a*) crops grown as pure stands and (*b*) crops grown in admixtures;

(2) Compare Single Cropping and Mixed Cropping in all its aspects,

an experiment was laid down.

Blocks :—

G	M	G C	M	G C
G C	N	G	G	M
N	G C	M	N	N
M	G	N	G C	G
1 acre observation plot (Native system)				

G = Groundnut.
G C = Guinea corn.
M = Maize.
N = Native system of mixed cropping (maize, groundnuts and guinea corn).

Size of plots = one-fifth acre.

Crops.	Date of Planting.	Date of Harvesting.
Maize	28th June	24th September
Groundnut	4th July	30th November
Guinea corn	16th July	17th December

The crops in the "Single" plots were planted on the same dates as the similar crops in the "Mixed" plots. Cultivations and harvestings were carried out on the same dates in both systems.

Method of Planting :—

Maize.—In both systems the maize was planted on 4-foot ridges in single rows. The holes were 1 foot 6 inches apart, and two to four seeds were dropped into each. Later the plants were thinned, the aim being to leave one to two seedlings per hole.

Groundnut.—In both systems the groundnuts were also planted 1 foot 6 inches apart in single rows. In the Mixed Crop plots the groundnuts were planted between the maize plants.

Guinea Corn.—In both systems the guinea corn was planted in double staggered row on 4-foot ridges. The plants in each row were 3 feet apart and four to five seeds were put in each hole.

In the Single Crop plots the plants were thinned to two to three, while in the Mixed Crop plots one to three plants were left to grow.

RESULTS AND YIELDS.

In the latter case many plants failed to reach maturity because of the presence of the maize crop for three months. The growth of the others was retarded, and at the time of the maize harvest the

difference between the Single Crop and Mixed Crop guinea corn was very marked. Later, the plants made good growth, and although never attaining the height and girth of the guinea corn in the Single Crop plots, yielded almost similarly heavy heads. At a time when the crop was beginning to ripen the leaves were stripped by locusts, but it is thought that the decrease in yield which resulted, besides being general over the area, was relatively extremely small.

TABLE I.

YIELDS IN LBS.

Block.	Maize.		Groundnut.		Guinea Corn.	
	Single.	Mixed.	Single.	Mixed.	Single.	Mixed.
1	74	60	7	8.5	73.5	53.5
2	81	80	14	22	31.5	17
3	54	42	12	12	52.0	47
4	75	49	17	9	70.0	40
5	92	66	16	6	61.5	51
Totals ..	376	279	66	57.5	288.5	208.5
Means ..	75.2	59.4	13.2	11.5	57.7	41.7

SINGLE CROP PLOTS VERSUS MIXED CROP PLOTS.

Maize.— $\overline{x} = +15.8$ lbs.
$t = 3.35$.
$\therefore$ P is between 0.02 and 0.05.

Therefore there is a significant difference in yield in favour of single cropping.

Groundnut.— $\overline{x} = +1.7$ lbs.
$t = 0.92$.
$\therefore$ P is between 0.4 and 0.5.

Therefore there is not a significant difference between the yields from the two systems.

Guinea Corn.— $\overline{x} = +16.0$ lbs.
$t = 3.98$.
$\therefore$ For $n = 4$ P is between 0.02 and 0.01.

Therefore there is a significant difference in yield in favour of single cropping.

TABLE II

YIELDS AS PERCENTAGE OF MEAN OF SINGLE CROP PLOTS.

Block.	Maize.		Groundnut.		Guinea Corn.	
	Single.	Mixed.	Single.	Mixed.	Single.	Mixed.
1	98	80	53	64	127	93
2	108	106	106	166	55	29
3	72	56	91	91	90	81
4	100	65	129	68	121	70
5	122	88	121	46	107	89
Mean ..	100	79.0	100	87.0	100	72.4

In Table III, below, an arbitrary method is used for comparison of the productive capacity of a plot of ground and "single" and "mixed" systems.

TABLE III.

Block.	Single.	Mixed.
1	93	237
2	90	291
3	84	228
4	117	203
5	117	223
Totals ..	501	1,182
Mean ..	100	236

The percentages of the means for single crop yields are summed, *e.g.*, for plot 1, $\frac{98 + 53 + 127}{3} = 93$.

Now, from the area represented, the percentages for mixed cropping are $80 + 64 + 93 = 237$, all from the single plot. Thus though the figures are arbitrary (means of percentages), they show the difference between the produce for a single area. The means of these figures are necessarily 100% in the single crop plot, but add up to 236 in the mixed crop plot.

ANALYSIS OF COSTS.

TABLE IV.

The labour costs of the trial were as follows :—

Operation.	Single Crops.												Mixed crops.					
	Maize (1 acre).			Groundnut (1 acre).			Guinea Corn (1 acre).			Total (3 acres).			Experimental (1 acre).			1 acre Observation Plot.		
	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Clearing and burning ...	0	5	1½	0	5	1½	0	5	1½	0	15	4½	0	5	1½	0	4	9
Ridging ...	0	7	3	0	7	3	0	7	3	1	1	9	0	7	3	0	6	3
Sowing and filling blanks	0	4	0	0	6	7½	0	2	6	0	13	1½	0	13	1½	0	7	9
Weeding and thinning ...		*		0	12	9	0	4	3	0	17	0	0	4	3	0	6	3
Moulding ridges	0	7	6	0	4	9	0	7	9	1	0	0	0	7	9	0	5	6
Harvesting ...	0	8	4½	0	5	0	0	4	3	0	17	7½	0	17	7½	1	7	9
Total ...	1	12	3	2	1	6	1	11	1½	5	4	10½	2	15	1½	2	18	3

* This maize did not require weeding. One moulding was sufficient, and during this operation the plants were thinned.

The area of the yield trial was too small to permit of labour costs being trustworthy for economic large-scale production. In addition, the division of the area into one-fifth-acre plots has the effect of increasing the costs for each operation when contract labour is employed. For purposes of comparison the labour costs on the observation plot of Mixed Cropping are shown. This plot was a compact one.

TABLE V.

YIELD PER ACRE.

Crop.	Single.	Mixed.	1 Acre Observation Plot of mixed Crops, adjoining Experiment.
	lbs.	lbs.	lbs.
Maize (threshed and dried)	376	279	448
Groundnut (in shell)	66	57.5	104
Guinea corn (threshed grain) ...	288.5	208.5	256

TABLE VI.

COMPARATIVE LABOUR COSTS ON THE BASIS OF EQUIVALENT YIELD.

Crop.	Single Cropping.	Mixed Cropping (1 acre).
	£ s. d.	
Maize (0.74 acre)	1 4 2	—
Groundnut (1.00 acre)	2 1 6	—
Guinea corn (0.72 acre)	1 2 5	—
Total (2.46 acres)	£4 8 1	£2 15 1½

Unless near a main road, where occasionally travellers are employed by the farmer to clear his land, the custom is either family labour or mutual aid by the villagers, with no payment of cash wages. Labour costs can, however, be interpreted as a figure which measures the amount of effort expended in producing the foodstuffs. The above costs are an indication of the comparison from that point of view of the two systems, and it is therefore not surprising to see that Mixed Cropping is the general rule.

SUMMARY.

It was to be expected that the crops grown singly on an area of ground would yield more than the similar crops in admixture on an equal area. The experiment showed that this supposition was borne out in fact.

1. Significant differences were found in both maize and guinea corn, but the crop of groundnuts in both cases was badly diseased, with the result that no significant difference could be established.

(*a*) The differential response in favour of Single Cropping as compared to Mixed Crop maize amounted to 25.8%.

(*b*) The differential response in favour of Single Crop guinea corn as compared to Mixed Crop guinea corn amounted to 27.7%.

When, however, the yields of total produce from the two systems was compared, on the basis of equal acreages, striking differences are apparent. This is brought out in Table III.

2. One acre of Mixed Crops yielded 279 lbs. maize,
,, ,, ,, 57.5 ,, groundnuts,
,, ,, ,, 208.5 ,, guinea corn,

while, in order to obtain the corresponding figures from the Single

Crop system, the following acres of land would have to be cultivated :—

Maize	0.74 acre
Groundnut	1.00 ,,
Guinea corn	0.72 ,,
Total	2.46 acres

i.e., 1 acre of land under Mixed Cropping yielded the same quantity of produce as 2.46 acres of land cultivated on the Single Crop system.

As a preliminary trial, and under the conditions which existed, this result shows up the superiority of Mixed Cropping.

Further trials would, however, be necessary to show if this superiority could be maintained in subsequent years.

PAPER No. XXII.

MAIZE MANURIAL TRIALS—KUMASI.

COMPILED BY H. B. WATERS.

In the year 1926 an area of rather more than 1 acre was laid down for manurial experiment with maize by Mr. T. Hunter at the Kumasi Experiment Station. The area, which is flat and uniform in appearance, had not been under cultivation for some seasons. The soil is a sandy loam overlying a gravelly subsoil.

This piece of land was divided into twenty-four blocks of one-twentieth of an acre each, with paths between, and each one-twentieth of an acre block was subdivided into three one-sixtieth plots, thus giving the seventy-two small plots required for the experiment. The layout is shown in the plan facing p. 194.

The cropping has consisted of two crops of maize each year as follows :—

		Sown.	Reaped.
1926.	No early crop ..	—	—
	Maize (late crop)	Sept., 1926 ..	January, 1927.
1927.	Maize (early ,,)	March, 1927 ..	July, 1927.
	Maize (late ,,)	Sept., 1927 ..	January, 1928.
1928.	Maize (early ,,)	March, 1928 ..	July, 1928.
	Maize (late ,,)	Sept., 1928 ..	January, 1929.

The yield records for the early maize crop in 1927 have, unfortunately, been lost, and therefore cannot be included in the analysis of results.

The manures used are shown in the following table :—

	Manure.	Amount per Plot of 1/60th Acre.	Equal to lbs. per Acre.
(a)	Basic slag ..	.. $2\frac{1}{2}$ lbs.	.. 150
	Sulphate of potash	.. $\frac{2}{3}$ lb.	.. 40
	Dried blood ..	.. $1\frac{1}{4}$ lbs.	.. 75
(b)	Basic slag ..	.. $7\frac{1}{2}$,,	.. 450
(c)	Sulphate of potash	.. 2 ,,	.. 120
(d)	Dried blood ..	.. $3\frac{3}{4}$,,	.. 225
(e)	Basic slag ..	.. $3\frac{3}{4}$,,	.. 225
	Sulphate of potash	.. 1 lb.	.. 60
(f)	No manure ..	.. Nil.	.. Nil.

These manures have been applied once a year, usually before the early crop. Three applications have been made altogether, viz., in September, 1926, March, 1927, and March, 1928. After the plots had been dug in preparation for planting, the manures were put on by hand and stirred in about a week before sowing the maize. Each plot has received the same manurial treatment each year. Thus any immediate effect of the manures should have been felt by the "early" crops (planted in March), any residual effect by the "late" crops (planted in September), and any accumulative effect by the 1927 and 1928 crops, especially the latter.

In addition to the manures, two other factors were introduced, namely, depth of tillage and the use of green manures. In applying "shallow" tillage the soil was dug, prior to sowing, to a depth of about 6 inches by forking, and in applying "deep" tillage the depth was 12 inches. Various kinds of green dressings were tried.

The arrangement of the various treatments is shown clearly in the plan of the "layout of the plots." There are twelve plots of each manurial treatment and twelve "no manure" plots. The arrangement of the plots on the ground conforms to no particular system, but no two plots carrying the same manurial treatment are contiguous.

Of the twelve plots for each manurial treatment :—

3 received shallow tillage and no green manure.
3 ,, ,, ,, ,, green manure.
3 ,, deep tillage ,, no green manure.
3 ,, ,, ,, ,, green manure.

Thus, in the whole experiment, there were thirty-six plots for each of the treatments : shallow tillage, deep tillage, no green manure and green manure.

In this experiment the maize has always been sown on the same day with an equal number of grains at a spacing of 3 feet by 3 feet. The sowing has been done on the flat, not on ridges or heaps, and the stands (3 feet by 3 feet) have been thinned to single plants. Except for the treatments under test already described, the maize has received the same subsequent treatment with regard to stirring, earthing up, etc. At harvest the following records have been made for each plot :—

Number of stands (of single plants) surviving at harvest time.
Number of ears or cobs.
Weight of grain.

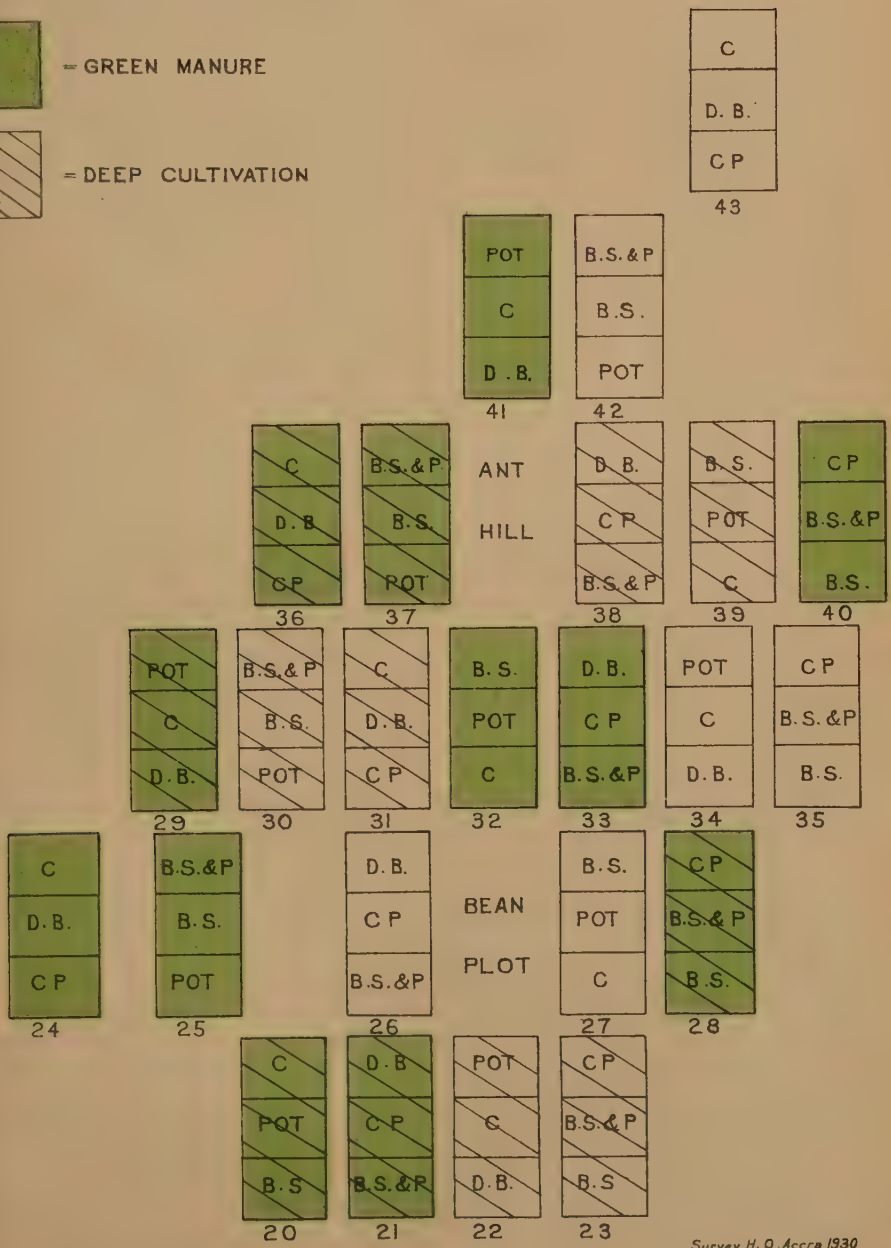
The survival rate of plants has not been high, due to the attacks of the corn-stalk borer, *Physoderma*, and also to wind storms and to Smut. In the case of the four harvests considered in this paper the survival rate has averaged 30%, 45%, 52% and 40% (given in chronological order).

LAY-OUT OF PLOTS

C = CONTROL
CP = COMPLETE
B.S = BASIC SLAG
B.S&P = BASIC SLAG & POTASH
POT = SULPHATE OF POTASH
D.B. = DRIED BLOOD

= GREEN MANURE

= DEEP CULTIVATION



Survey H. Q. Accra 1930

MEAN YIELDS FOR MANURIAL TREATMENTS.

TABLE I.

Actual Weights of Grain Reaped.

Treatment.	Mean Weights of 12 Plots in pounds per Acre.			
	Sept., 1926, to Jan., 1927.	Sept., 1927, to Jan., 1928.	Mar., 1928, to July, 1928.	Sept., 1928, to Jan., 1929.
(*a*) Complete	807	847	1,278	689
(*b*) Basic slag	810	849	1,440	662
(*c*) Sulphate of potash ..	906	731	1,442	593
(*d*) Dried blood ..	646	660	1,360	680
(*e*) Basic slag and sulphate of potash ..	747	816	1,265	701
(*f*) No manure ..	707	664	1,426	589

TABLE II.

Weights of Grain Calculated to a Full Stand of Plants (4,840 *Plants per Acre*).

	Mean Weights of 12 Plots calculated to a Full Stand of Plants in pounds per Acre.			
	Sept., 1926, to Jan., 1927.	Sept., 1927, to Jan., 1928.	Mar., 1928, to July, 1928.	Sept., 1928, to Jan., 1929.
(*a*) Complete	2,846	1,805	2,568	1,829
(*b*) Basic slag	2,497	1,847	2,882	1,565
(*c*) Sulphate of potash ..	2,638	1,594	2,650	1,512
(*d*) Dried blood ..	2,189	1,435	2,466	1,585
(*e*) Basic slag and sulphate of potash ..	2,688	1,878	2,723	1,766
(*f*) No manure ..	2,320	1,544	2,434	1,436

In Table No. I the figures for yields of grain are the actual recorded weights, uncorrected and unadjusted in any way. In Table No. II the figures have been calculated to a full stand of plants by making use of the "survival rate" figures recorded for each plot; they are similar for comparative purposes to figures of "yields per 100 plants," and, in fact, the latter could be calculated by dividing each figure in Table No. II by 48.4.

There are various ways of extracting the meaning of these tables of yields, but perhaps the clearest method in this case is by

the construction of tables showing the differences in the yields of the "treatment" plots as compared with the "no manure," or control, plots. This has been done in Tables III and IV.

INCREASE IN YIELD DUE TO MANURIAL TREATMENTS

TABLE No. III (FROM TABLE No. I).

Percentage Increases in Yield. Actual Weight of Grain Reaped.

Treatment.	No. of Plots.	Percentage Increase (+) or Decrease (—) of Manured Plots as compared with the "No Manure" Plots.				
		Sept., 1926, to Jan., 1927.	Sept., 1927, to Jan., 1928.	Mar., 1928, to July, 1928.	Sept., 1928, to Jan., 1929.	Mean.
(*a*) Complete	12	+ 14	+ 28	— 10	+ 17	+ 12
(*b*) Basic slag	12	+ 15	+ 28	+ 1	+ 12	+ 14
(*c*) Sulphate of potash ...	12	+ 28	+ 10	+ 1	+ 1	+ 10
(*d*) Dried blood	12	— 9	— 1	— 5	+ 15	—
(*e*) Basic slag and sulphate of potash	12	+ 6	+ 23	— 11	+ 19	+ 9
(*f*) No manure	12	—	—	—	—	—

TABLE No. IV (FROM TABLE No. II).

PERCENTAGE INCREASES IN YIELD.

Weight of Grain Calculated to a Full Stand of Plants.

Treatment.	No. of Plots.	Percentage Increase (+) or Decrease (—) of Manured Plots as compared with the "No Manure" Plots.				
		Sept., 1926, to Jan., 1927.	Sept., 1927, to Jan., 1928.	Mar., 1928, to July, 1928.	Sept., 1928, to Jan., 1929.	Mean.
(*a*) Complete	12	+ 23	+ 17	+ 5	+ 27	+ 18
(*b*) Basic slag	12	+ 8	+ 20	+ 18	+ 9	+ 14
(*c*) Sulphate of potash ...	12	+ 14	+ 3	+ 9	+ 5	+ 8
(*d*) Dried blood	12	— 6	— 7	+ 1	+ 10	—
(*e*) Basic slag and sulphate of potash	12	+ 16	+ 22	+ 12	+ 23	+ 18
(*f*) No manure	12	—	—	—	—	—

An examination of Tables III and IV brings out the following facts :—

(*a*) The plots receiving Dried Blood gave yields identical with the "No manure" plots.

(*b*) The plots receiving Basic Slag and Sulphate of Potash, singly and in combination, gave increased yields over the "No manure" plots of from 8% to 18%.

(*c*) The plots receiving Basic Slag gave the greatest increases in yield.

Consequently, the following reasonable deductions can be made :—

(i.) That the Dried Blood treatment had no effect on yield. (There is some evidence (from Table IV) of a slight accumulative beneficial effect, but this is not statistically significant.)

(ii.) That the Basic Slag treatment resulted in an increased yield. (In the case of Basic Slag and Sulphate of Potash there is little, if any, evidence of accumulative effect.)

(iii.) That the Sulphate of Potash treatment had a beneficial effect.

The yield figures have been analysed statistically * by the method known as "Analysis of Variance." The broad fact was established that the observed variation in mean yield between different treatments could not have been merely the result of chance. Further, it was determined that the ineffectiveness of the Dried Blood treatment and the benefit resulting from the application of Basic Slag were results that could be classed as statistically significant.

INCREASE DUE TO BASIC SLAG.

The evidence all goes to show that the beneficial effect of the various treatments was in the following order :—

1. Complete treatment .. Greatest increase in yield.
2. Basic slag and potash.
3. Basic slag.
4. Potash
5. Dried blood .. .. No increase in yield.

Basic Slag was included in Treatments 1 and 2 (bracketed) and constituted Treatment 3. No further emphasis is required as to its beneficial effect, nor as to the greater effect of Basic Slag as compared with Sulphate of Potash, Dried Blood and "No manure." There is, of course, nothing to show in these results as to the extent to which the increases were due to phosphates or due to free lime, which is invariably a constituent of basic slag. This awaits solution.

The failure of Dried Blood should not be too highly stressed. It is possible that a more soluble nitrogenous fertiliser applied at some other time in the year might do better, say, as a top dressing in October or November, when the nitrogen content of the soil is low.

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* By G. Cowan.

SHALLOW VERSUS DEEP TILLAGE AND GREEN MANURE VERSUS NO GREEN MANURE.

TABLE V.

	Sept., 1926, to Jan., 1927.	Sept., 1927 to Jan., 1928.	Mar., 1928, to July, 1928.	Sept. 1928, to Jan., 1929.
A. *Actual Weights of Grain Reaped.*				
(i.) *Mean weights of 18 plots.*		*Pounds per Acre.*		
Shallow tillage. No green manure	830	740	1,290	485
Shallow tillage. Green manure	806	825	1,176	610
Deep tillage. No green manure	765	727	1,544	792
Deep tillage. Green manure	681	753	1,464	722
(ii.) *Increase (+) or decrease (—) of Green manure as compared with No green manure.*		*Percentages.*		
With shallow tillage	— 3	+ 11	— 9	+ 26
With deep tillage	— 11	+ 4	— 5	— 9
(iii.) *Increase (+) or decrease (—) of Deep tillage as compared with Shallow tillage.*				
With no green manure ...	— 8	— 2	+ 20	+ 63
With green manure	— 16	— 9	+ 24	+ 18
B. *Weights of Grain calculated to a full stand.*				
(i.) *Mean weights of 18 plots.*		*Pounds per Acre*		
Shallow tillage. No green manure	1,723	1,748	2,703	1,671
Shallow tillage. Green manure	2,685	1,765	2,488	1,655
Deep tillage. No green manure	2,468	1,566	2,513	1,538
Deep tillage. Green manure	2,240	1,658	2,776	1,598
(ii.) *Increase (+) or decrease (—) of Green manure as compared with No green manure.*		*Percentages.*		
With shallow tillage	— 1	+ 1	— 8	— 1
With deep tillage	— 9	+ 6	+ 10	+ 4
(iii.) *Increase (+) or decrease (—) of Deep tillage as compared with Shallow tillage.*				
With no green manure ...	— 9	— 10	— 7	— 8
With green manure	— 17	— 6	+ 12	— 3

The main figures for a study of the secondary treatments, "green manure *versus* no green manure" and "light *versus* deep tillage," are given in Table V above. It will be seen from A (ii.) and B (ii.) that the use of green manure resulted in no consistent increase or decrease in yield. It should be mentioned that the failure of this treatment may have been due to the method of management, for the use of green manures for arable crops in the tropics is a subject which is not yet thoroughly understood. But, with the method used, the use of green manures made no measurable difference to the yields.

From A (iii.) in Table V it would appear that deep tillage, while having a depressing effect of the yield in the beginning, was having an accumulative beneficial effect, which was greatest in the absence of green manuring. From B (iii.), however, no such deductions can be made. The inference is that the increased yields in the deep tillage plots were due to a greater survival of plants at harvest than in the shallow tillage plots. Whether this higher survival rate was due to the effect of deep tillage or not cannot be definitely stated, and the supposition that the effect of deep tillage was accumulative falls to the ground. The figures of yields have been examined in still greater detail to see if any connection could be traced between depth of tillage and the various manurial treatments ; this analysis showed that no significant relation could be traced between them.

CONCLUSIONS.

The yield results of maize in a Manurial Trial at Kumasi over a period of four seasons are analysed. Strong evidence is advanced to the effect that the application of

(*a*) Basic Slag and Sulphate of Potash led to definite increases in yield, and that Basic Slag had the greatest effect. (The increases were from 8% to 18%.)

(*b*) That the application of Dried Blood, in the manner and quantity prescribed by the trial, had no effect on the yield.

(*c*) That shallow, as compared with deep, tillage gave no measurable effect either on yield or on the effect of manurial treatments, except that survival of plants to harvest was greatest in the case of the deeply tilled plots.

(*d*) That green manuring had no measurable effect either on the yield or on the effect of manurial treatments.

This trial, while admittedly defective in some technical particulars, has served a useful purpose in supplying strong corroborative evidence as to the efficiency of basic slag locally.

PAPER No. XXIII.

YIELDS OF MAIZE ON NATIVE FARMS.

By I. N. ACQUAH.

During the last season observations have been made on ten plots of maize on native farms in the neighbourhood of Asuansi Investigational Station. At planting time square plots of one-fortieth of an acre (33 feet by 33 feet) were demarcated by small concrete posts.

The farms were chosen in different positions round the station, and within a mile of the boundaries, so that they could all be visited in a day. The farmers treated the plots just as the rest of their farms, and the method of cultivation was that common to the district. After cutting down the two- to four-years' growth of bush (or, in one case, forest) it was burnt off, and the seed-corn sown at irregular spaces without any cultivation. Four seeds per hole is common practice. It was not possible to visit the farms every day to collect data of the cultivation given subsequent to planting, nor considered advisable to make too many visits. The customary practice is to do the first weeding with a hoe, and give a subsequent weeding, using a cutlass, when the corn is half-grown. Data were collected at harvest and the ears weighed. Grain weights were not obtained, as it would necessitate transporting the grain to the station buildings for drying if the results were to be reliable. In doing this there is a possibility of misunderstanding, and it was decided not to attempt grain weights in the first year.

Discussion of Data Collected.

The table gives the data collected. The soil is a loam and characteristic of the district, with the exception of a strip along the river, and patches of yellow clay. The land is undulating, and most farms are on a slope. The direction of slope is given in the table, and where very slight, brackets have been used.

Of the ten farms, one was after-forest and the rest after a previous corn crop—one after four years' fallow, three after three years, and five after two years. The practice is to grow a crop every third or fourth year.

The planting dates are spread over seven weeks, and harvesting

OUTSIDE MAIZE PLOTS. ASUANSI, 1929.

No.	Position.	Soil.	Aspect.	History of Plot.	Date of Planting.	Date of Harvesting.	Growing Period. Days.	No. of Stands.	No. of Stalks.	No. of Ears.	Wt. of Ears. lbs.	Stalks per Stand.	Wt. per Ear. lbs.	Calculated Wt. of Grain per Acre.
1	S.W.	Sandy Loam	S.E. slope	Corn + 2 yrs. fallow	April 1	Sept. 5	157	44	200	165	56	4.5	0.34	1,438
2	S.	Sandy Loam	Lowland (S. slope)	Corn + 3 yrs. fallow	Mar. 3	Aug. 28	178	45	238	230	80	5.3	0.35	2,055
3	S.W.	Loam	Highland (N. slope)	Corn + 2 yrs. fallow	April 18	Sept. 12	147	72	304	254	79	4.2	0.31	2,028
4	S.	Loam	Highland (W. slope)	Corn + 2 yrs. fallow	April 6	Sept. 5	152	73	313	156	40	4.3	0.26	1,027
5	S.E.	Loam	(S. slope)	Corn + 2 yrs. fallow	April 16	Sept. 5	142	75	340	258	86	4.5	0.33	2,210
6	S.E.	Loam	Highland (N. slope)	Corn + 4 yrs. fallow	April 1	Aug. 31	152	40	140	168	75	3.5	0.45	1,927
7	E.	Loam	Highland (N. slope)	Corn + 3 yrs. fallow	April 23	Sept. 24	154	48	141	140	48	3.0	0.34	1,232
8	E.	Loam	(N. slope)	Corn + 3 yrs. fallow	April 23	Sept. 24	154	49	146	104	35	3.0	0.34	899
9	W.	Loam	(W. slope)	Forest	April 8	Aug. 26	140	80	252	201	91	3.2	0.45	2,336
10	N.	Loam	(N. slope)	Corn + 2 yrs. fallow	March 27	Aug. 28	154	43	148	133	47	3.5	0.35	1,207
						Means	153	57	222	181	64	3.9	0.35	1,636
						Per acre	—	2,280	8,880	7,240	2,560	—	—	1,636
												Standard duration		503

over four weeks. The rainfall during the planting period is shown below.

DAILY RAINFALL.

Date.	Feb.	March.						
	24	2	3	9	12	17	20	28
Inches	0.07	0.77	0.05	0.03	0.06	1.41	0.06	0.95

Date.	April.										May.
	1	6	9	11	12	14	17	18	19	24	1
Inches	0.30	2.16	0.07	0.38	0.07	0.48	0.20	0.05	0.23	0.36	0.12

In most cases planting was done on the day on which a shower of rain fell, or whilst the soil was moist after rain.

Yields.

The yield per acre of dry grain, in the last column, is calculated by using a constant conversion factor obtained from station yields. Grain weight = 0.642 by ear weight. These yields vary from 899 to 2,336 lbs. per acre, the largest yield coming from the farm following forest.

From the data no significant correlations are found between yield and slope, spacing, date of planting, length of growing period, or the size of ear. With only ten readings, however, it could hardly be expected, and it is not possible to conclude that there are no correlations. Certain points of interest, however, emerge.

(1) The period from planting to harvest is about twenty-two weeks.

(2) Spacing is equivalent to 4 feet by 4 feet.

(3) Four stalks per stand is average.

(4) Each stand produces 3.2 ears on an average.

(5) The mean yield per acre is 1,636 lbs. of dry grain, against a mean of 1,714 obtained on the Agricultural Station.

The chief interest of the work lies in the education of the farmer concerning rigid recording, and may be a beginning of collaboration between the farm and the Investigational Station in trying out varieties and treatments.

PAPER No. XXIV.

YIELDS OF MAIZE AND CASSAVA IN THE GOLD COAST.

SUMMARISED BY W. T. O. MAIDMENT.

In 1922 experiments were laid down in various stations throughout the Colony and Ashanti to determine the yields of maize and cassava for the production of Power Alcohol.

The experiment was made standard for each station on which it was being carried out, with the exception that local varieties of cassava were used for planting purposes.

The object of this paper is to set out the yields of cassava and maize which were obtained in the course of these trials, no attempt being made to discuss whether these crops can be grown economically in this country for the production of commercial alcohol. Trials took place at various stations throughout the Colony and Ashanti, but complete figures are obtainable only from Kumasi Agricultural Station, Ejura Agricultural Station in Ashanti, and the Communal Coconut Plantation at Abra near Cape Coast. In the Eastern Province trials were started in 1923 at Kibi and Kpedsu, but were run only for one year, except at Kibi, where two crops of maize were grown, so these figures are included for maize only.

The experiments at Kumasi, Abra and Ejura were conducted on 2 acres of previously uncleared land and arranged as follows :—

1922	1923	1924	1925	1926
Maize	Cassava	Cassava	Maize	Cassava
Cassava	Cassava	Maize	Cassava	Cassava

Thus figures should be available of three crops of both maize and cassava from each of these three stations, but, unfortunately, at Ejura Agricultural Station the cassava trials were carried out only over two crops of cassava.

MAIZE.

The crop was planted in April at Ejura, Abra, Kibi and Kpedsu, and in March or late February at Kumasi, which are considered to be the best periods for planting in these districts. At Kumasi and Ejura a second crop was planted in September, but owing to drought

and insect pests the plots seldom gave an average yield, and these figures have been disregarded. As originally laid down the plots were divided into four parts to test various distances of planting, which were as follows: 3′ × 1′, 3′ × 2′, 3½′ × 1′ and 3½′ × 2′.

KUMASI.

Yields of Maize-grain.

Year.	Date planted.	Distance apart.	Date reaped.	Yield per ¼ Acre. lbs.	Yield per 1 Acre. lbs.
1922	13/3/22	3′ × 1′	31/7/28	378	1,476
	,,	3½′ × 1′	,,	389	
	,,	3′ × 2′	,,	362	
	,,	3½′ × 2′	,,	347	
1924	26/2/24	3′ × 1′	18/7/24	128	628
	,,	3½′ × 1′	,,	172	
	,,	3′ × 2′	,,	194	
	,,	3½′ × 2′	,,	134	
1925	10/3/25	3′ × 1′	10/8/25	584	1,685
	,,	3½′ × 1′	,,	381	
	,,	3′ × 2′	,,	479	
	,,	3½′ × 2′	,,	241	

Average yield of one season over a period of 3 years = 1,263 lbs. per acre.

ABRA COCONUT PLANTATION.

Yields of Maize-grain.

Year.	Date planted.	Distance apart.	Date reaped.	Yield per ¼ Acre lbs.	Yield per 1 Acre. lbs.
1922	April	3′ × 1′	August	171	641
	,,	3½′ × 1′	,,	139	
	,,	3′ × 2′	,,	239	
	,,	3½′ × 2′	,,	92	
1924	April	3′ × 1′	August	183	759
	,,	3½′ × 1′	,,	224	
	,,	3′ × 2′	,,	197	
	,,	3½′ × 2′	,,	155	
1925	April	3′ × 1′	August	227	652
	,,	3½′ × 1′	,,	175	
	,,	3′ × 2′	,,	188	
	,,	3½′ × 2′	,,	62	

Average yield of one season over a period of 3 years = 684 lbs. per acre.

EJURA.

Yields of Maize-grain.

Year.	Date planted.	Distance apart.	Date reaped.	Yield per ¼ Acre. lbs.	Yield per 1 Acre. lbs.
1922	28/4/22	3′ × 1′	9/9/22	—	710
	,,	3′ × 1′	,,	—	
	,,	3′ × 1′	,,	—	
	,,	3′ × 1′	,,	—	
1924	5/3/24	3′ × 1′	2/7/24	49	231
	,,	3½′ × 1′	,,	56	
	7/3/24	3′ × 2′	1/7/24	61	
	,,	3½′ × 2′	,,	65	
1925	13/3/25	3′ × 1′	10/7/25	257	1,491
	,,	3½′ × 1′	,,	315	
	14/3/25	3′ × 2′	13/7/25	468	
	,,	3½′ × 2′	,,	451	

Average yield of one season over a period of three years = 810 lbs. per acre.

KIBI.

Yields of Maize-grain.

Year.	Date planted.	Distance apart.	Date reaped.	Yield per ¼ Acre. lbs.	Yield per 1 Acre. lbs.
1923	April, 1923	3′ × 1′	August, 1923	343	1,127
	,,	3½′ × 1′	,,	371	
	,,	3′ × 2′	,,	217	
	,,	3½′ × 2′	,,	196	
1925	16/4/25	3′ × 1′	7/9/25	505	1,880
	,,	3½′ × 1′	,,	480	
	,,	3′ × 2′	,,	445	
	,,	3½′ × 2′	,,	450	

Average yield of one season over a period of two years = 1,503 lbs. per acre.

KPEDSU

Yields of Maize-grain.

Year.	Date planted.	Distance apart.	Date reaped.	Yield per ¼ Acre. lbs.	Yield per 1 Acre. lbs.
1923	April, 1923	3′ × 1′	August, 1923	238	868
	,,	3½′ × 1′	,,	322	
	,,	3′ × 2′	,,	140	
	,,	3½′ × 2′	,,	168	

In 1924 the crop at both Kumasi and Ejura Stations was very poor. At Kumasi this was due to drought and an attack by corn-stalk borer. The rainfall records shows that in May only 2.93 inches of rain fell, as against an eighteen-year average of 6.49 inches. The rainfall from March to June inclusive was 20.33, against an average of 26.34 inches for eighteen years.

At Ejura the crop was spoilt by drought at the flowering stage, which prevented the cobs from swelling. Maize starts to flower from eight to ten weeks after planting, and the rainfall returns show that there was a shortage of rain during that time. The rainfall for May was 5.36 inches in eight days, against a nine-year average of 7.78 inches in 10.6 wet days.

A difference of 2 inches at this critical period is probably enough to account for the poor crop.*

At Abra in 1922 growth was not satisfactory owing to abnormal weather. June was a month of floods, as 18.12 inches of rain were recorded, and of this 8.32 inches fell in one day. July and August were also exceptionally dry, only 0.49 inches being recorded during the two months. In 1924 the rainfall was lower than the average, and crows damaged the crop. In 1925 very heavy rains fell in June, with the result that part of the plot was under water and the crops suffered in consequence.

It will be seen from the above set of figures that the yield varies greatly in different districts and also in different years in the same district. The latter fluctuation is due to abnormal climatic conditions and the incidence of disease and insect pests, whilst the former depends chiefly on the type of soil on which the crops are grown.

Average Yield.

The average yield of 1 acre of maize, calculated over twelve crops and from five different centres, works out at 1,029 lbs. per acre. As this includes the very poor crops harvested in Ashanti in 1924 it is safe to assume that, given normal conditions of rainfall, disease and insect pests, the average yield of maize throughout the Colony and Ashanti is close on ½ ton per acre.

Yields and Planting Distances.

From the tables of yields it will be seen that in the Eastern Province yields are considerably higher when the planting distances

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* J. W. Smith, in his book on Agricultural Meteorology, states that in America maize flowers in July, and in the State of Ohio, if the rainfall for this month is three inches, an average yield of 30.3 bushels per acre is obtained. When, however, the rainfall is five inches and over, the average yield is 38.1 bushels per acre. This shows the importance of rainfall at the flowering period.

are close (*i.e.*, 3′ × 1′ and 3½′ × 1′). At Ejura, however, this is just the reverse. If, however, the yields from the plots planted 3′ × 1′ and 3½′ × 1′ from each of the five centres are added together and compared with the yield of the other two plots the following is obtained :—

Yield from 22 plots planted 3′ × 1′ and 3½′ × 1′ gave 6,077 lbs. grain.

Yield from 22 plots planted 3′ × 2′ and 3½′ × 2′ gave 5,351 lbs. grain.

It will be seen that in general throughout the Colony and Ashanti the greatest yields are obtained by planting the maize at a distance of 3′ × 1′ or 3½′ × 1′.

The figures of yields do not show any significant difference between these two planting distances, *i.e.*, 3′ × 1′ and 3½′ × 1′.

Yield from 11 plots planted 3′ × 1′ gave 3,063 lbs. grain.
,, 11 ,, 3½′ × 1′ ,, 3,024 ,,

CASSAVA.

The object of this trial was to obtain information on two subjects, namely, the actual yield of crop and the length of time for which the crop should be allowed to remain in the ground in order to give the most economic yield. With this object in view part of the crop was harvested at intervals of two months from six to twelve months after planting, and thence at intervals of three months until eighteen months old. In some instances a whole row of cassava was harvested ; in others a definite number of stands were dug up, the roots weighed, and the yield per acre calculated.

In all cases the crop was planted 3′ × 3′, thus giving 4,840 stands to an acre.

Kumasi.

Date planted.	Date reaped.	Age in Months.	No. of Stands reaped for Test Weighings.	Calculated Weight per Acre Fresh Roots. lbs.
27/3/22	29/ 9/22	6	166	10,967
,,	28/11/22	8	144	12,203
,,	29/ 1/23	10	173	12,880
,,	27/ 3/23	12	147	16,520
,,	29/ 6/23	15	176	15,867
,,	27/ 9/23	18	139	8,890

KUMASI—*continued.*

Date planted.	Date reaped.	Age in Months.	No. of Stands reaped for Test Weighings.	Calculated Weight per Acre Fresh Roots. lbs.
27/3/23	27 /9/23	6	192	8,867
,,	27/11/23	8	187	12,250
,,	27/ 1/24	10	190	13,183
,,	27/ 3/24	12	100	8,843
,,	27 /6/24	15	100	11,200
,,	27/ 9/24	18	68	9,147
27/3/25	27/ 9/25	6	66	11,660
,,	27/11/25	8	68	12,669
,,	27/ 1/26	10	65	14,049
,,	28/ 3/26	12	67	14,303
,,	27/ 6/26	15	61	21,820
,,	27/ 9/26	18	64	13,640

ABRA.

Date planted.	Date reaped.	Age in Months.	No. of Stands reaped for Test Weighings.	Calculated Weight per Acre Fresh Roots. lbs.
27/7/22	27/ 1/23	6	—	—
,,	31/ 3/23	8	24	22,960
,,	31/ 5/23	10	28	18,810
,,	31/ 8/23	12	25	27,440
,,	31/11/23	15	20	29,680
,,	31/ 1/24	18	19	31,360
31/4/23	31/10/23	6	40	14,000
,,	31/12/23	8	33	16,800
,,	28/ 2/24	10	30	18,800
,,	28/ 4/24	12	40	20,720
,,	31/ 7/24	15	40	26,880
29/4/25	10/11/25	6	404	4,760
,,	10/ 1/26	8	300	6,720
,,	10/ 3/26	10	294	7,140
,,	10/ 5/26	12	291	7,560
,,	8/ 8/26	15	192	9,660
,,	10/11/26	18	169	10,920

EJURA (TWO CROPS ONLY).

Date planted.	Date reaped.	Age in Months.	No. of Stands reaped for Test Weighings.	Calculated Weight per Acre Fresh Roots. lbs.
27/3/22	27/ 9/22	6	111	10,322
,,	27/11/22	8	111	12,082
,,	27/ 1/23	10	111	16,827
,,	27/ 3/23	12	96	19,660
,,	27/ 6/23	15	96	21,580
,,	27/ 9/23	18	96	23,910
28/4/23	28/10/23	6	120	10,953
,,	28/12/23	8	120	12,777
,,	28/ 2/24	10	50	21,780
,,	28/ 4/24	12	50	29,000
,,	28/ 7/24	15	50	25,984
,,	28/10/24	18	395	21,952

Yields and Time of Harvesting.

As will be seen from the above sets of figures, the yields vary greatly from year to year, both in the same and in different districts. It is probable that, owing to the method of calculating the yields, some of the returns were inaccurate. This is clearly seen in instances where, in the early stages, the returns show a lower yield for a longer period of growth.

The Kumasi returns and the 1923 Ejura returns show that after the fifteenth month the weight of fresh roots decreases. This is due to the roots becoming fibrous and woody, with a consequent reduction in starch content.*

At Kumasi it was observed that after the fifteenth month the roots were attacked by *Fomes lignosus*,† which reduced the yield to a considerable extent.

The average yield of cassava on three experiment stations calculated over different periods of growth is as follows :—

						Tons.
Average yield per acre at			6 months	calculated over	7 crops	= 4.6
,,	,,	,,	8	,, ,,	8 ,,	= 5.9
,,	,,	,,	10	,, ,,	8 ,,	= 6.8
,,	,,	,,	12	,, ,,	8 ,,	= 7.9
,,	,,	,,	15	,, ,,	8 ,,	= 9.0
,,	,,	,,	18	,, ,,	7 ,,	= 7.6

* Sir Frederick Nathan, Power Alcohol Adviser to Fuel Research Board of Department of Scientific and Industrial Research, "Cassava as a Source of Power Alcohol," October, 1923.

† "Gold Coast Plant Diseases," by Bunting and Dade, p. 73.

It is advisable, therefore, as a general rule in the Colony and Ashanti to harvest the cassava crop fifteen months after planting to obtain the greatest yield of starch. As an article of food, however, the crop should be harvested after twelve months, as after this period the roots are not readily saleable.

The average yield of 1 acre of cassava grown until allowed to mature is 9 tons.

This compares very favourably with yields experienced in other countries.*

Yield of cassava in	Southern Nigeria	= 3–10 tons per acre.	
,, ,,	Northern Nigeria	= 4 tons per acre.	
,, ,,	Ceylon	= 4.5–8.2 tons per acre.	
,, ,,	Mauritius	= 4.3 tons	,,
,, ,,	British Malaya	= 9–12 tons	,,
,, ,,	Sierra Leone native farms	= $2\frac{1}{2}$ tons	,,
,, ,,	Nyasaland	= 6 tons	,,
,, ,,	Uganda	= 8 tons	,,

* Sir Frederick Nathan, Power Alcohol Adviser to Fuel Research Board of Department of Scientific and Industrial Research, "Cassava as a Source of Power Alcohol," October, 1923.

PAPER No. XXV.

YIELDS OF GUINEA CORN.
KPEVE INVESTIGATIONAL STATION.

By H. K. HEWISON.

The following table records the planting data and the yields obtained from various plots of guinea corn planted during 1929 :—

TABLE.

Plot.	Planting Date.	Area in Acres.	Planting Distance.	Nominal No. of Plants per Stand.	No. of Heads possible.	No. of Heads Harvested.	Wt. of Grain in lbs.	Equiv. Grain per Acre.	Heads per lb. Grain.
A	28/4/29	0.10	3′ × 1′	3	4,356	1,150	51.5	515.0	22.33
B	28/4/29	0.10	3′ × 1′	3	4,356	774	23.5	235.0	32.93
C	28/4/29	0.10	3′ × 1′	3	4,356	1,269	69.75	697.5	18.19
D	28/4/29	0.10	3′ × 1′	3	4,356	1,186	87.0	870.0	13.63
E	28/4/29	0.10	3′ × 1′	3	4,356	1,179	100.5	1,005.0	11.73
No.									
1	30/7/29	0.16	2′ × 2′	2	3,630	1,856	175.5	1,061.0	10.58
2	27/5/29	0.25	3′ × 4′	3	2,722	1,400	205.0	820.0	6.83
3	16–17/7/29	0.25	3′ × 3′	3	3,630	3,553	214.0	856.0	16.60
4	3/8/29	0.25	3′ × 3′	3	3,630	3,463	205.5	822.0	16.85

The five areas designated by the letters A, B, C, D and E in the above table refer to guinea corn sections of a replicated rotation trial.

The seed employed was of a white variety grown and marketed in Togoland, and the amount used was at the rate of 11 lbs. per acre. Sowing during the month of April was in accordance with local practice ; the actual date (the 28th) a matter of convenience.

Overcrowding, due to too close planting, resulted in attenuated growths, and the plots suffered severely during the abnormal rain, totalling 11.81 inches, which fell on three occasions during the third week of August.

During that period a considerable proportion of the crop was laid.

Growth continued during early September, however, and many of the recumbent stems made vertical growth and emerged from the tangled mass.

Flowering was first recorded on September 30th, and was general by the first week of October (twenty-two to twenty-three weeks from sowing).

The crop was harvested on November 30th, thirty-one weeks from sowing.

Plot No. 1 of the foregoing table was a stand of a red variety of guinea corn obtained from the Northern Territories.

At the time of the phenomenal August rains the plants were not a month old, and by comparison with the plots on the rotation trial the damage done was not extensive.

The plants flowered on October 15th, roughly eleven weeks from sowing, and heads were harvested on December 16th, when the stand was twenty weeks old.

Plots Nos. 2, 3 and 4 were on irregular areas of land not required for other trials and were sown for the purposes of selection, seed supply maintenance and poultry food. The seed used was of the same variety and from the same source as that sown in the five rotation plots.

The stand of No. 2 was from eleven to twelve weeks old at the time of the heavy August rains already referred to. The plants commenced flowering on October 1st, eighteen weeks from sowing, and the crop was harvested on December 14th, some eleven weeks later.

It may be noted that the heads from this stand gave the highest grain-weight value, the average being 2.34 ounces clean grain per head.

Plots Nos. 3 and 4 were unaffected by the conditions that so seriously damaged the earliest planted stands. Flowering commenced in Plot No. 3 on October 10th and in Plot No. 4 on the 22nd of the same month, by which time the stands were twelve and rather less than twelve weeks old respectively.

The crop of Plot No. 3 was reaped on December 31st, 1929, at twenty-four weeks, and that of Plot No. 4 on January 2nd, 1930, the plants then being about twenty-two weeks old.

SUMMARY.

1. The yields of nine plots of guinea corn are recorded.
2. The diverse conditions under which the various plots were grown prevent any inference being drawn from the yields with regard to the effect of time of planting, spacing or plants per stand.
3. The need for a series of systematic yield trials is being met by work in progress.

PAPER No. XXVI.

THE GROUNDNUT INDUSTRY OF NZIMA.

By R. B. POBEE.

Groundnuts are an important economic crop all along the littoral of the Nzima Divisions, for although there is no export trade in groundnuts from the Gold Coast, there is a large domestic demand from the larger centres of population. This area provides supplies for Sekondi and the mining areas on the Sekondi-Kumasi Railway. This cultivation is all the more interesting because it is almost entirely carried on by women, the men only lending assistance when heavy clearing is required.

The development of this industry can be ascribed to several reasons. The main occupations of the male members of the population in this area were timber cutting and fishing, although recently, with the establishment of the rice factory at Esiama, increasing amounts of rice are being grown each year. The women, with their husbands absent or engaged in other than agricultural pursuits, desiring some means of lucrative employment, soon discovered that the easily worked soil of the sand-bar between the lagoon and the sea afforded an opportunity for the cultivation of groundnuts. Any surplus production found a ready sale, so, actually, quite an important industry has developed from what was an attempt merely to provide a contribution towards housekeeping expenses.

The table below gives the distribution, estimated acreage and production of the crop for the villages along the littoral between the Ancobra River and the Ivory Coast boundary. This data was derived from information given by the women farmers themselves. The method adopted to obtain this information was to take the mean of the total production of a group of growers and multiply that result by the number of growers in each village. A number of plots were measured and the yields recorded from these areas were used to calculate the acreage from the production of each village—the yield figure used being twelve bags of approximately 80 lbs. each or 960 lbs. of undecorticated groundnuts per acre.

The annual production is thus estimated at 7,398 bags, or just over 260 tons, which, valued at 10s. per bag—the local price—makes the industry worth between £3,600 and £3,700 per annum. This amount is never realised, as the growers reckon to retain about one-quarter of their crop to supply seed and for their own domestic

Name of Village.	Estimated Acreage.	No. of Bags Unshelled Nuts.	Name of Village.	Estimated Acreage.	No. of Bags Unshelled Nuts.
1. Asanta ..	2.5	30	17. Kaboku ..	8.0	100
2. Asamko ..	0.8	10	18. Beyin ..	25.0	300
3. Kikam ..	8.0	100	19. Nerekazo ..	1.7	20
4. Esiama ..	83.0	1,000	20. Aloen ..	18.0	220
5. Asrunun ..	4.0	48	21. Kangan ..	25.0	300
6. Mpein ..	10.0	120	22. Twenani ..	4.0	50
7. Nyensi ..	6.7	80	23. Ajesa ..	20.5	250
8. Bakanta ..	3.0	40	24. Alengenzure	20.5	250
9. Sensrin ..	33.0	400	25. Zinabo ..	37.0	450
10. Krisan ..	6.0	80	26. Bonyeri ..	50.0	600
11. Eikwe ..	29.0	350	27. Kobnaswaso	4.0	50
12. Ngalikpole	25.0	300	28. Ebwazo ..	37.0	450
13. Ngalichi ..	16.5	200	29. Tobo ..	20.5	250
14. Beku ..	16.5	200	30. Atwibanso	25.0	300
15. Anochi ..	8.0	100	31. Epung ..	4.0	50
16. Atwabo ..	50.0	600	32. Half-Assini	8.0	100
			Total	610.2 acres	7,398 bags.

requirements. Still the remainder must prove a useful addition to the domestic budgets of Nzima, particularly as this area, unlike so many other districts, has no established permanent crop like cacao.

Two groundnut crops are grown each year, the more important being cultivated on the free sandy soil close to the sea, from April to September, and the other a mile or less inland, on the higher and therefore drier parts of the lagoon, which are inundated in the wet season, from October to March. The beach crop is the more profitable one, as generally not only is the yield heavier and more regular, but less labour is required in its preparation. All the preparation that is required in this case is that the land should be hoed about 4 to 5 inches deep and that all material likely to hamper the development of the crop should be removed. It is usual for the women to sweep their plots before planting with a palm-leaf brush in order to remove twigs, roots and other débris. These beach plots are utilised year after year, but only one crop of groundnuts is taken in each twelve months. After harvesting, the land may be left fallow, or more generally " Ngatia " (Nzima)—*Citrullus vulgaris*—is sown. Two varieties of " Ngatia " are commonly grown, " Ngatia fufule," the white climber, and " Ngatia kokole," the red-yellow-creeper. The latter is generally grown on the beach, whilst the former is more favoured in the inland plots, where trees, etc., left in the original clearing provide a suitable means of support without which

this variety will not bear fruit. The seeds of the "Ngatia" are extensively used locally in the making of soup, and command a ready sale at double the price paid for groundnuts.

Inland plots require more preparation, as the soil is heavier and the vegetation stronger, and labour is usually hired to clear the scrub, as this is rather beyond the capabilities of the women themselves. It is usual when breaking in new areas to grow corn and cassava for one or two years so as to give the roots and stumps time to decay in order to reduce the heavy cost of clearing.

The land on the littoral is individually owned, and generally groundnut farmers pay an annual minimum rental of 3s. per plot 60 feet by 60 feet, approximately one-twelfth of an acre, in advance. Most growers have certain rights to their beach plots, but the majority pay rent for the inland areas.

With continued cropping year after year these groundnut farms tend to yield less, and as a corrective a dressing of sand fresh from the beach is applied at the rate of about 2 tons per acre. On the heavier soil of the inland plots the benefit of this dressing may be attributed to the improved mechanical condition of the soil, but it also appears to be effective on the sandy beach plots, which would lead one to suspect that there is some other factor as well.

The nuts for planting are not shelled until the land is ready for sowing. The seeds are then carefully sorted and all those suspected of having lost their vitality are discarded. The sound, healthy seeds are measured in pots, each grower knowing the number of these measures required to sow her plot. The "pot" which is universally used in this industry as the standard of measurement is of about 6 pints capacity: 40 pots of undecorticated groundnuts, producing 20 pots or 100 lbs. of shelled nuts, are required to sow an acre, and one woman can sow about one-fifth of an acre per day.

The method of sowing is that holes 2 inches deep and 3 to 6 inches apart are made with the local type of hoe and a single seed is inserted and covered with soil pushed along by the sower's foot. The hoes used are of two types, both having blades about 4 inches wide, curved slightly inwards, and wooden handles 18 inches long. The difference between these hoes is that the "Kwanle" (Nzima), the most common type, has a peg head, whereas the "Twebe" has the loop method of attaching the head to the shaft.

The beach crop is sown early in April, so that it is germinated and established before the main rainy season, "Forsese," has set in, and harvested during the comparatively dry spell in August between the "Forsese" and the "Bokiley" (small rainy season). The inland crop is sown in September and October, and gets the benefit of the small rainy season, and is harvested in January or February during the dry season.

Under favourable conditions the seeds germinate in three to four days, and the first flowering period occurs about a month later. There are two or three distinct flowering periods at intervals in each crop. Before flowering takes place the farms are all carefully weeded —the most troublesome weed is the nut-grass (*Cyperus rotundus*), known locally as "Mbubule." This is all the attention the crop receives except that the depredations of the black and white crow "Kokosere" are guarded against until the seeds have germinated, and a fence of palm leaves interwoven between upright sticks about 4 inches apart has to be maintained around each farm to prevent damage by rodents. A certain amount of loss is caused each year by Rosette Disease known as "Amputin," but no effort is made to control it until harvest time, when the affected plants are pulled up and burnt.

Harvesting commences when the leaves of the plants begin to droop. The plants are pulled up bodily by hand. After a block of the plot has been thus dealt with, and all the nuts which come up with the plants are collected, the ground is hoed to expose any nuts which have not come up. The nuts are now exposed to the sun on mats for drying, and whilst this is in progress any immature or damaged nuts are picked out to be utilised immediately.

After drying, the amount required for seed and domestic purposes, usually about one-quarter of each individual's production, is stored, undecorticated, in round baskets holding about 1 cwt. each, hung up in the kitchen so that the smoke and heat may prevent the admission of weevils and mould. The remainder is quickly sold to local agents for transport to the centres of consumption.

There are three varieties of groundnuts grown on any considerable scale in Nzima. The nuts from these varieties are fairly distinct in colour and size, although the leaves and flowers present no appreciable differences. These are :—

"*Nzima Ehule*" (Nzima groundnuts). This local variety is the most popular, yielding about 8 to 9 cwts. per acre on the average, and it sells readily on account of its flavour, being appreciated locally. It takes four to five months to come to maturity.

"*Bouake and Jimbo Ehule.*" These, as the name implies, are varieties introduced from Bouake and Jumbo, in the Ivory Coast, where they are extensively grown. The rather whitish coloured nuts are large, generally two or three seeded, but, owing to lack of flavour, are not so readily saleable and are not extensively cultivated. The yield is similar to the previous variety.

"*Himinle Ehule.*" This variety is superior to the other two in taste an d flavour as well as in the yield. It has a shorter growing period : when planted in April it is ready for harvest-

ing in June, a most unsuitable time on account of the rain then prevailing; moreover, the seeds are particularly lively, and germination sets in immediately if there is any delay at all in the reaping. This drawback, together with a local superstition that it is unlucky to use this variety for culinary purposes owing to the deep red colour of the testa, has prevented it from becoming more popular. The yields recorded show that it yields on the average around 15 cwts. per acre.

PAPER No. XXVII.

THE COLA INDUSTRY IN THE WESTERN PROVINCE OF ASHANTI.

By J. C. MUIR.

Second in importance to the cacao crop in Ashanti comes Cola, which has for long been a source of income to the Ashantis. The trade, which is in fresh nuts, is entirely in the hands of Africans, with the result that knowledge as to the quantities available in the various centres could only be obtained laboriously.

Figures for Sale of Cola.

During the course of a census of cacao production in the Western Province, the opportunity was taken to obtain the figures for average Cola sales shown in the attached table. These figures were obtained by visiting all villages in the Cola-growing areas of the Province and making enquiries at every house as to the average annual sales of this crop.

The quantity of cacao leaving the Province was checked at the gates leading from Sunyani, Ahafo and Wenchi districts, and so substantial was the agreement between the census figures and the gate records (5% difference) that it is considered the Cola figures for average sales can also be accepted with a large degree of confidence.

Rainfall of Cola-growing Zone of the Western Province.

The bulk of the indigenous Cola in the Province is found in the region bounded by the 60-inch rainfall curve, other principal centres falling in areas receiving between 55 and 60 inches of rain.

Deep Soil a Feature of the Cola Areas.

The most dense part of the Cola belt of the Province centres around Tekyimentia and Dema, in which places red laterite soil merges into a red subsoil of great depth. In the Cola-growing areas around Ntroso in Ahafo district this soil type occurs, as does also a deep grey-brown alluvium. It would appear that the plant is more exacting than cacao in its requirements, deep retentive soil and high rainfall (50 to 60 inches) being a feature of the centres in the Western Province, in which the industry has persisted on a commercial scale.

Map Showing Distribution.

On the attached map a brown line encloses the Cola belt of Ashanti, as shown in the Department of Agriculture's map, "Dis-

MAP OF WESTERN ASHANTI

SHOWING

COLA AREAS

SCALE 1:1,000,000 OR 1·014 INCHES = 16 MILES.

Miles 10 5 0 10 20 30 40 Miles

30′ 2°

Ofuman
Amoma
Tainso
Ekrobio
Wenchi
Sekwa
Yefri
Nkunsia
Besedua
Tuobodom
Awurawa
Nkoranza
R. Tain
Trumuso
30′ 30′
Tanoso
Abontiem
Berekum
Chira
Akumadan
Suatre
Dumasua
Sunyani
R. Tano
Nkinkaso
Atroni
Abofaw
Tepa
7° 7°
Amoyu
Acherensua
Fwidiem
Wiawso
R. Tano
R. Oti
Mim
Domiabra
Fufuo
Kunsu
Goaso
Mpesaso
Bori
Kumasi
Dadiasuaba

GOLD COAST
Wa
Tamale
Kumasi
Accra
Axim
Takoradi

Cola Centres
500 Head Loads
Indicates Cola area
Provincial Boundary

SURVEY H. Q. ACCRA, 1930

tribution of Principal Commercial Crops, 1928" (Year-Book, 1928), but from the data given in the table it is possible to demarcate the natural areas of the Western Province with greater precision.

In this map Cola areas are coloured buff, average sales within each area being shown by black dots, each dot representing 500 head loads.

Average Sales Distinct from Total Production.

The total of 28,779 loads, shown in the table, gives the average annual sales of Cola from the Province, but this amount is not to be confused with total production.

In the first place, there is no market for small defective nuts, while medium sizes find but a limited demand.

Nuts for export are primarily selected for size and then minutely inspected by the purchaser, who discards such as show traces of weevil attack or other defects.

In the centres where indigenous Cola is common there is generally over-production, and a supply of selected nuts can be reaped to furnish any small increase in demand. Whenever the demand is excessive the medium-sized nuts can be disposed of at reasonable prices. On this account the total Cola crop is probably from two to three times greater than the average sales.

Quantity Sold and Total Quantity Available.

In the table sales are given in head-loads of 2,000 to 2,500 nuts, as made up at the growing centres. Packages in such places were weighed and found to average about 80 lbs. At this figure sales for the Western Province of Ashanti would aggregate to some 1,054 tons. Making allowance for over-production and the sale of small nuts, the writer considers that 2,000 to 2,500 tons of Cola is an outside figure for the total tonnage of nuts available from existing areas in the Western Province of Ashanti.

Destination of Western Province Cola.

We now know definitely that the bulk of the Cola from this area goes North by way of Bamboi and Buipe Ferries, the quantity going South to rail-head having been checked at Bechem and Tanosu gates, and having proved to be less than 50 tons.

Consignments going South are lorry-borne, whereas those for the North are conveyed by head or donkey transport. The average head-load, as previously explained, is 80 lbs., while the load per donkey is 160 lbs. (or two head-loads), carried in panniers fixed to the saddle.

AVERAGE SALES OF COLA IN HEAD-LOADS OF 80 LBS.

A. Sunyani District.

Village.	Loads of 80 lbs.	
1. *Biadan Marketing Centre.*		
Senasii	10	
Biadan	300	
		310
2. *Chirra Marketing Centre.*		
Chirra	854	
Esuakwa	51	
Tananaw	100	
		1,005
3. *Techire Marketing Centre.*		
Techire	1,114	
Adrubun	957	
Tanosu	717	
Ampenkro	10	
Wankojo	50	
Contrajesu	512	
		3,360
4. *Teppa Marketing Centre.*		
Susanso	162	
Yamfu	436	
Boma	472	
Esukese	104	
Asubompang	59	
Teppa	226	
Kwakoni	6	
Akwasiase	267	
Mabang	141	
		1,873
5. *Sunyani Marketing Centre.*		
Atroni	384	
Sunyani	250	
Odumase	158	
Nkwaben	30	
		822
6. *Nkwanta Marketing Centre.*		
Kojokuma Krom	30	
Konkromase	60	
Dedeboa	40	
Brofoyedru	20	
Nkwanta	745	
		895
Carried forward		8,265

Village.	Loads of 80 lbs.	
Brought forward		8,265
7. *Bechem Marketing Centre.*		
Mensim	200	
Heanemgoase	100	
Bremang	10	
Ahiruam	250	
Sakronum	500	
Bechem	140	
Brosankro	35	
Kosu..	31	
Nyesua	20	
Jumwo	360	
Impasem	45	
		1,691
8. *Tekyimentia and Dema Marketing Centre.*		
Kumfuyase	10	
Deakumaso	218	
Wonsontri	20	
Yironimuso	63	
Bonfwa and Beredi	64	
Nkwachere	5	
Diawusso	65	
Tenasu I	30	
Tenasu II, III and Minihin	90	
Awaham I to III	45	
Nobesu and Mantukwa	30	
Tekyimentia	2,260	
Eselso	40	
Minoku I	45	
Beredi	125	
Twatanso	102	
Toni	35	
Atakrusikrom	30	
Mpahaha	40	
Asuadefu	25	
Kwamekusikrom	35	
Kwesiantim..	20	
Kwamensakrom	30	
Mmokuja	27	
Ekuapere	20	
Praku..	60	
Subrisu	50	
Dema	5,000	
Duntakro	55	
Yabrema	30	
Nsuansa	15	
Carried forward		9,956

Village.	Loads of 80 lbs.	
Brought forward		9,956
Twapiase	25	
Aframsu	15	
Intadiem	20	
Inkokyil	37	
Yaw Bogu	210	
		8,991
Total for Sunyani..		18,947

B. Ahafo (Goaso) District.

Nkassaim and Ntotroso Marketing Centre.

Nkassaim	125	
Nobekaw	20	
Akrodie	7	
Mim	12	
Ntotroso	1,774	
Kanyase	941	
Fwidiem	377	
Gyedu	99	
Wamahinsu..	91	
Total for Ahafo-Goaso		3,446
Total for Sunyani..		18,947
Total for Sunyani and Ahafo-Goaso		22,393

C. Wenkyi District.

Tekiman, Tanosu and Krobo Marketing Centre.

Tekiman	248
Buoyem	50
Ofuman	100
Tuobodam	203
Bisidam	40
Boase	10
Sensena	5
Ehansua	126
Asempanye	20
Kuntunasu	46
Tadiesu	4
Tanosu	596
Tra	2
Anyimedu	22
Tankofiano	10
Brodikro	12
Kenten	125
Asuoye	71

Village.	Loads of 80 lbs.	
Brought forward		22,393
Jema	5	
Temponum	21	
Anyinabrim..	7	
Ampekro	5	
Atronisu	73	
Akrofrom	352	
Awuruwa	32	
Drobosu	87	
Wiawiano	4	
Bifosu	3	
Koasi	1	
Trumesu	1	
Niheresua	12	
Atum	2	
Wenkyi	17	
Ekrobi	5	
Chenchenasi	3	
Ekusimesu	8	
Bimedi	10	
Ayesu II	1	
Asan..	2	
Nkwayesu	98	
Agoso	623	
Benkwai	100	
Old Krobo	878	
Nsuetem	76	
New Krobo	270	
Total for Wenkyi..		4,386

D. Kintampo District.

Estimated production	2,000
Total	28,779

PAPER No. XXVIII.

A NOTE ON SHEA YIELDS AT YENDI.

By J. E. SYMOND.

In 1922 a 20-acre block of land was marked off near Yendi, a good district for Shea trees, and investigations commenced to discover the effect of time of burning the undergrowth on the yield of fruit.

In the 1927 Year-Book, Captain G. C. Coull publishes these results to the end of 1927 (Paper No. XXIII). The treatment there outlined was continued for the 1928 season, after which time it was decided to discontinue burning and observe the effect of cultivation.

The weeded-control plot was continued unchanged and trials laid out to test the effect of the following treatments :—

(*a*) Deep forking.
(*b*) Interplanting with Bengal beans. Turned in at end of rains.
(*c*) Interplanting with pigeon peas. Loppings turned in at end of rains.
(*d*) Cattle manure.
(*e*) Heavy mulching.

Treatments (*a*), (*b*) and (*c*) were carried out on the plots which had previously been burnt. Table I opposite gives a comparison of the yields per acre of these plots under different treatments, from which it will be seen that large increases have resulted from cultivation. The year 1929 was reckoned a good year for Shea, which is borne out by the yield from the control plot, but even taking this into account the beneficial effect of cultivation is obvious.

To express the yield in terms of pounds of kernels per acre is misleading, however, as the density of the Shea trees varies considerably in the different plots. In Table II, therefore, the yield is shown as mean yield of kernels per fruiting tree. Unfortunately no count of the number of trees in fruit was taken for the years 1924–28, and it is obvious from the 1929 count that the trees do not all fruit every year. In future an annual count of trees fruiting will be taken on all plots, and observations taken on 100 individual trees as to whether or not they bear annually.

Yield for these five years in Table II is therefore calculated on the lower number of fruiting trees.

TABLE I.

Plot.	Acreage.	Treatment.		No. of Shea Trees in bearing.		Yield in lbs. of Dry Kernels per Acre.						
		1923–28	1929	1923	1929	1923	1924	1925	1926	1927	1928	1929
A	2·52	Clean weeded ...	Clean weeded ...	489	436	103.9	80.1	64.3	93·5	49.6	44.4	118.6
B	3.04	Burnt as soon as possible ...	Forked deeply ...	404	294	11.2	53.3	92.4	31·7	11.8	46·0	90.8
C	3·18	Burnt 10 days after Plot B	Planted with pigeon peas ...	473	371	39.3	29·7	75·5	37.7	13.4	35.2	128.3
D	2.72	Burnt 10 days after Plot C	Planted with Bengal beans. Later dug in	305	205	2.6	54·6	100·7	38.3	22.1	30.8	98·5
E	3.09	Burnt 10 days after Plot D ...	Forked deeply ...	585	552	—	17.4	44.6	21.3	15.2	24·9	171.2

TABLE II.

Plot.	Average Yield in lbs. of Dry Kernels per Tree reduced from Table I.						
	1923	1924	1925	1926	1927	1928	1929
A	0.53	0.46	0.37	0.54	0.28	0.25	0.68
B	0·09	0.55	0.95	0.32	0.12	0.47	0.94
C	0.26	0.25	0.64	0.32	0.12	0.29	1.10
D	0.02	0.72	1·33	0.50	0.29	0.40	1.30
E	—	0.09	0.24	0.12	0.08	0.14	0.95

Note.—For the years 1924–28 the yield has been calculated on the number of trees fruiting in 1929.

From this it will be seen that the highest yield is obtained from the plot interplanted with Bengal beans. Treatments which were commenced only in 1928, and for which there is therefore no comparison with previous years, gave the following results :—

Plot.	Treatment.	Mean Yield per Tree.
S ..	Cattle manure, 2 tons per acre ..	85 lbs. kernels.
Z ..	Heavy mulching	79 ,, ,,

Table I is of importance in showing how low are yields in country which is unprotected from fire, and what a tremendous acreage must be covered to collect any large tonnage of Shea kernels. In this connection the yield of three Shea trees on Tamale Station in 1929 is interesting.

Two are fine specimens, and all have been protected from fire for many years. They gave yields of 11 lbs., 9½ lbs. and 4 lbs. of kernels respectively. They are isolated trees, however, and it remains to be seen whether protected trees in a fairly dense stand will ever approach these yields.

PAPER No. XXIX.

THE SHEA TREE (Butyrospermum Parkii) IN THE NORTHERN TERRITORIES.

By H. L. HILL.

Introduction.

Officers of the Department and others have from time to time written papers * in connection with the shea butter industry of the Northern Territories. This article is written as an illustrated addition to the previous publications, and is restricted to a brief description of the tree and its fruits, native methods of extracting the butter, local trade and prices, transport facilities, a reference to a consignment of shea nuts to Europe, and the possibilities of creating an export trade.

The shea tree.

As has been previously written, the tree is found nearly all over the Northern Territories and tends to occur apparently in belts. The tree is easily recognisable by its bark and foliage, both of which are quite different from what is commonly known as the false shea tree (*Lophira alata*). The distinctive horizontal and vertical cracking of the corky bark is depicted in Plate I, fig. 2, of this paper.

During the *harmattan* † the trees are mostly devoid of foliage, but regain their foliage at different

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* Report by Conservator of Forests on Shea Butter Trees in the Northern Territories. N. C. McLeod (Sessional Paper VIII, 1921–22).

The Shea Butter Industry of the Northern Territories. G. C. Coull (Sessional Paper VII, 1925–26).

Agricultural Survey in Connection with the proposed Northern Territories Railway. G. C. Coull (Year-Book, 1927, Department of Agriculture).

Distribution and Yields of Shea Butter Nut Trees in the Northern Territories. G. C. Coull (Year-Book, 1927, Department of Agriculture).

Geographical Distribution of Principal Local Crops. A. C. Miles (Year-Book, 1928, Department of Agriculture).

Results of a Trial Shipment of Shea Nuts. J. E. Symond (Year-Book, 1928, Department of Agriculture).

Foodstuffs in the Dagomba District. G. C. Coull (Year-Book, 1928, Department of Agriculture).

Minor Industries in the Northern Territories. G. C. Coull (Year-Book, 1928, Department of Agriculture).

† Dry northerly wind from the Sahara which blows during the months of December to February.

Plate I.

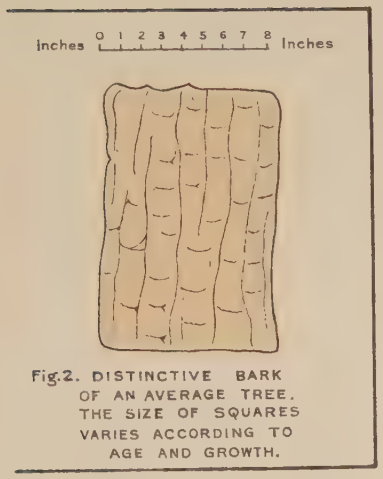


Fig.2. DISTINCTIVE BARK OF AN AVERAGE TREE. THE SIZE OF SQUARES VARIES ACCORDING TO AGE AND GROWTH.

Fig.1. A YOUNG GOOD YIELDING SHEA TREE ABOUT TWELVE FEET HIGH— FROM A PHOTOGRAPH.

Fig. 3. BUDDING-SHOOT ON AN OLD TREE (OBSERVED IN MIDDLE OF MARCH)

SURVEY H. Q ACCRA, 1930.

ANCH OF A YOUNG TREE
UNDANT FRUITING AND NEW
MIDDLE MAY. FRUIT NOT
LY DEVELOPED.

Fig. 2.
LEAF AND FRUIT FORMATION—
NOT FULLY DEVELOPED.

times. The exact cause of this difference is at the moment doubtful, but there seems to be some indication that age has something to do with it, the younger trees regaining foliage much later. The older trees regain early in February, the middle-aged in March. Flowering starts also at different times, but generally shortly after the foliage is regained on the older trees.

To avoid going into a lengthy description of the fruiting, illustrations are given in Plate III, fig. 2, which show clearly the stages from budding to the full grown fruit (which, on an average, is about the size of a large plum). As soon as the petals fall the fruit starts to take form.

Towards the end of May the fruit ripens and falls to the ground and is then collected. The green outer part is edible, and when this is removed there is a brown shell containing the kernel left. As shown in Plate IV, fig. 3, more than one of these nuts sometimes are to be found in the fruit, but generally there is only one. The tree and the fruits contain a fair amount of latex, and the presence of this in the kernel is apparently a drawback for manufacturing purposes. It is anticipated that this difficulty can be overcome.

Plate III, fig. 1, shows the younger trees where buds, flowers and fruit appear almost simultaneously.

There appears to be some considerable variation of yield of fruit. Trees of very medium growth give an abundant yield, and during the short time that observations have been made for the purposes of this article the opinion was formed that for a year or two at least this yield is maintained and then decreases. This may or may not be so, and only observation over some years will prove whether this surmise is correct. The age at which these maximum yields occur is also doubtful, but it is surmised that it is in the neighbourhood of ten years.

Plate II, fig. 1, is of part of a branch of one of the trees referred to above showing a fair amount of fruit, but in a great many cases the fruiting is far more abundant. Trees of this yielding capacity are nearly all about the same size in growth and from 10 to 12 feet high (*see* Plate I, fig. 1). Girth, however, varies somewhat. It would no doubt be interesting to carry out some experiments in pruning, but it would take some time to obtain satisfactory results. Trees with prolific foliage appear not to yield so well.

In the past the natives have undoubtedly cut down many of the trees for fuel purposes, but there is an indication that they are beginning to realise the importance of preserving them. They do not seem to realise, however, the importance of removing epiphytic growths from those trees which are readily accessible to the villages and from which they collect their nuts yearly. Should there ever be an increase in the trade there is little doubt they will soon turn their attention to these matters, as they are good, hard-working farmers.

Native methods of extracting the butter from shea.

Three different methods were observed, the Dagomba, Nunumba and the Mamprusi. The Dagomba and Mamprusi methods are similar to one another, but that adopted by the Nunumba people is quite different.

Dagomba and Mamprusi.—After collection the shea nuts are first boiled and dried. The shell is then removed by light pounding in a mortar and winnowed from the kernels by allowing the kernels and shell to drop from a basket raised shoulder high over a basket placed on the ground during a fair wind. The kernels drop into the basket, while the wind carries the shell clear of the basket.

The kernels are then placed in a mortar and lightly pounded until sufficient fat has exuded to permit of stirring into a sticky mass, when it is placed in an earthenware pot on a fairly strong fire and stirred. It is then removed again to the mortar, where it receives considerable pounding, until it resembles melted nut chocolate.

From the mortar it is removed in small quantities, placed on a slanting slab of stone and rubbed over vigorously with another stone, which causes the sticky mass to trickle down the stone in a more liquid form on to a layer of sand or ashes placed to receive it. It is collected from the sand bed by hand and placed in a small calabash containing a small quantity of water.

It is stirred by hand, water being added from time to time, until the colour lightens, due to the fat starting to rise. In order to speed up the process a small quantity (a teaspoonful) of prepared shea butter is added and mixed with that in the calabash, and the mixture kneaded with the back of the fingers. More water is added and stirring backwards and forwards is continued. A distinct change in colour then takes place to a pinky white. More water is added and stirring continued in a rotary motion.

Plate 3.

Fig. 1.
(OBSERVED IN MIDDLE OF MAY)

Fig. 2.

SHEA FRUIT SHEWING STAGES OF DEVELOPMENT FROM FLOWER.

SURVEY H. Q. ACCRA, 1930

Plate 4

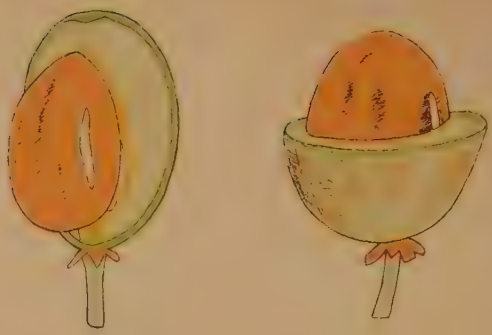
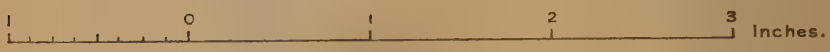


Fig. 1. SHOWING HOW NUT IS HELD.



SECTION OF KERNEL IN
ITS SHELL BEFORE DRYING.

A TYPICAL KERNEL
EXTERIOR.

Fig. 2.

SINGLE

TWIN

TRIPLE NUTS

Fig. 3.

SHEA FRUIT AND SEED.

The fat is now all on top and is removed to another calabash, any sand that has got in being left at the bottom of the first calabash. Water is added to the fat, and after a little stirring is replaced by fresh water until quite cleansed. The fat is then placed in an earthenware pot and heated over a fairly strong fire. It bubbles up and is stirred fairly continuously until it attains a black colour, when it is removed from the fire and allowed to cool off slowly. On top there is some greyish matter which is removed by a spoon and thrown away.

After a little cooling the black liquid fat is run off into a calabash, leaving a brownish residue in the pot. This is mostly small parts of the kernel which failed to be properly ground. The black liquid in the calabash on cooling solidifies and is the finished shea butter.

This demonstration was carried out by a Dagati woman, and is therefore likely to be the same as carried out by the Dagati people. The demonstration was made at Gambaga by the kind arrangement of Mr. G. F. Mackay, District Commissioner, Gambaga. A similar demonstration was observed at the village of Salampang, Western Dagomba district.

*Nanumba.**—The villages of Leprusi and Bekwaba in the Eastern Dagomba district were visited. The people there are Nunumbas, and the method adopted is similar to that carried out by the Konkombas. The nuts are merely collected and allowed to dry in the sun for a period of from ten to twenty days. The dried nuts are then vigorously rubbed over with a flat stone to break the shells off and the kernels are picked out by hand. They are then taken to a swish-† constructed kiln and placed over a slow fire for ten days, the kernels being covered by grass-matting or leaves.

Plate V shows the kiln in elevation and sectional elevation. The " bars " to hold the kernels are wooden and are about 4 feet above the fire level. About three baskets of kernels are placed over the fire at a time.

The kernels are turned over after five days in the kiln and taken out of the kiln on the tenth day, placed in a mortar and pounded until a dark chocolate-

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* I wish to thank Captain W. E. Gilbert, M.C., District Commissioner, Eastern Dagomba District, and Captain J. A. Armstrong, A.D.C., for their kind assistance during the whole of the shea operations in this district.

† Puddled clay.

coloured mass is formed. This is then removed and placed in an earthenware pot containing hot water and placed on a fairly strong fire. It is then stirred. To accelerate the extraction of the butter a small quantity of solution (made by squeezing the juice out of the leaves of a herb "Bungu" * (Dagomba) into a little water) is added. The contents of the pot are then allowed to bubble away on the fire, and gradually the butter is seen to rise to the top and is then removed by a spoon skimming the top. After the butter is removed cold water is added to the remaining solution, which brings any remaining oil to the top, which is skimmed off in two days' time and used for lighting purposes, and is not considered edible. The butter removed soon solidifies and is then ready for use. The people generally are not interested as to what happens to the latex contained in the kernels.

Local trade, prices, transport, etc.

Most of the present trade is local and there is a fair trade with Kumasi. The native women appear to have the trade entirely in their hands, the men taking no interest at all.

Quite a considerable amount of the prepared butter is sold in all the local markets, but it is sold by the calabashful rather than by weight. During the year 1928 11,204 loads of 60 lbs. each of shea butter passed southwards over the ferries.

The only transport at the moment is by lorry, and the charges vary from 10d. to 1s. per ton-mile. The distance from Tamale to Kumasi, the nearest railhead, is 236 miles. The cost, therefore, for sending a ton of kernels from Tamale to Kumasi ranges between £9 16s. 8d. and £11 16s. It therefore appears that not only will the price of the kernels have to come down considerably in order to start an export trade, but the cost of transport will also have to be reduced. Should a railway eventually be constructed to Tamale this will be possible.

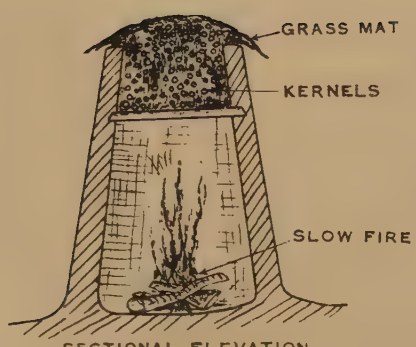
In going round the villages efforts have been made to persuade the women to sell the prepared kernels at a lower price than they have previously asked. Some of the villages on the Yendi-Tamale road, Daboija road, Kumbungu and Tampiong, have now agreed to drop from 1s. 3d. per kerosene tin to 9d. per tin next season. The difficulties and expense of transport have been fully explained, and there is every reason to hope some satisfactory arrangement will be made which should be

* *Ceratotheca sesamoides.*

Plate 15.

SHEA KILN

ELEVATION



SECTIONAL ELEVATION

SURVEY H. Q. ACCRA, 1930.

an inducement to traders to eventually come up here to purchase regularly.

Consignments of shea to Europe.

During 1928, 15 tons * of shea kernels were shipped to Europe at a loss, as was expected. During 1929, a further amount of 15 tons of kernels is to be purchased, but instead of shipping the kernels to Europe as previously done, the work of extracting the butter will be carried out at Tamale, presses and filters having, in 1929, been imported by the Department of Agriculture. It is at present not clear whether the users or manufacturers of this commodity prefer to purchase the kernels and extract the butter themselves or will be content with the purchase of the butter prepared in a tropical climate. There appear to be certain difficulties in packing the prepared butter, and when these difficulties are surmounted it will be interesting to compare the final costs of extracting, purchase of cans or drums, sealing the drums (and possibly casing them), with the cost of sending the bagged kernels to Europe. That there is a demand for shea there appears to be no doubt, despite the presence of the unsaponifiable matter, which appears to be about 7%. British West Africa exported, in 1915, 10,084 tons of kernels; in 1913, 9,420 tons; and in 1920, 9,905 tons. These figures are quoted in "long tons" of 2,400 lbs.

Possibilities of creating a regular export trade.

As has already been said, the two vital points are, firstly, the price of the kernels locally, and, secondly, the cost of sending consignments to the coast, whether the kernels or the extracted butter is sent. It appears that even at the existing price of kernels there is some market available which, although not showing a loss, does not show a sufficient profit to traders to cover the cost of sending a man up to the Northern Territories to buy shea. As we have been able to induce the native women to reduce their prices for kernels to meet this contingency, it is not improbable that the near future will see an increase in the exports. With the increase of exports of shea from the Northern Territories, the greater will be the possibilities of constructing a railway, even if it comes only as far as the Volta River at first, thereby somewhat reducing the cost to the coast. The question of demand remains, but should the supply be adequate at a reasonable price, there seems to be no reason why the demand should not be increased as the commodity becomes more readily available and better known.

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* J. E. Symond, Paper No. XXX., Year-Book, 1928, Department of Agriculture.

It is interesting to note that nearly all over Ashanti and the Colony shea butter from the Northern Territories is to be seen on sale at stores and on the stalls of the petty traders in the market-places. At Esiama, situated 320 miles from Tamale in a straight line, and on the coast, shea butter is sold in balls, the average weight of which is about 1 lb., and this realises a price of 1s. per ball (1s. per lb., or £112 per ton). The butter is sent from the north in calabashes of varying sizes, but possibly averaging 1 foot 6 inches in diameter and 9 inches deep, and the cost at Esiama is about £3. The Northern Territories shea butter has, in Appolonia, a serious competitor in the form of shea butter imported from the French Ivory Coast. This butter is considered by some natives to be better than that from the Northern Territories. The butter is shipped in sealed tins and also in barrels. I have had the opportunity of seeing both kinds of shipments. The butter in the tins, which hold about 2 to 3 gallons, is very yellow in appearance, due possibly to the fact that rum is mixed with it. In the barrels it presents a similar appearance to the Northern Territories butter. It is said that the tinned butter is not up to the standard of the barrelled butter. The exact cost I have been able to ascertain only roughly. For about 400 lbs. of butter in barrels the cost is about £12, or, roughly, £67 per ton. This is sold in the same manner, in balls at about 1s. per lb.; the trader thereby makes a profit at the rate of £45 per ton. Although occasionally used for cooking purposes, the more general use is for anointing the body, and for this purpose there appears to be quite a good demand. These prices of the local trade in shea are extremely interesting when compared with the very low price offered for it in Europe.

PAPER No. XXX.

MOISTURE AND MOULD IN COPRA UNDER WESTERN PROVINCE CONDITIONS.

By W. C. FISHLOCK.

Among problems arising in connection with the establishment of a copra industry in the Nzima part of the Western Province is that of the incidence of mould on stored copra.

It is well known that certain moulds, notably species of *Aspergillus*, do much damage to copra by the destruction of oil and the production of free fatty acids in it.

On the other hand, certain moulds may be regarded as harmless; more, their very presence indicates a well-dried copra, since they can only exist on copra containing a small percentage of moisture. These are the grey-green moulds (*Penicillium* spp.).

At the present time shipping facilities in the Nzima country are not good, and it is often necessary to store copra for lengthy periods. In these circumstances it is obvious that the question of the occurrence of various forms of moulds on stored copra becomes of importance.

With a view to gaining information regarding the incidence of moulds, and the degree of drying required in order that copra might be safely stored in the damp climate of Nzima, a series of experiments were started in 1928. These experiments have revealed much interesting and possibly useful and valuable information. It is the purport of the present paper to set out the information thus obtained.

It was discovered, early in the investigations, that pernicious moulds only occur on partly dried copra, that is, copra containing upwards of 7% or 8% of moisture. It has been clearly shown that well-dried copra, that is, copra containing not more than 6% of moisture, is immune to the attacks of pernicious moulds, *Aspergillus* spp., commonly known as black and brown moulds.

For investigational purposes, forty-seven separate lots of copra were carefully dried at intervals between July, 1928, and December, 1929. Each lot resulted from the drying of 100 lbs. fresh kernel. The average initial dry weight was 57.85 lbs.

It is usually assumed that the average moisture content of fresh kernel is about 48%. This is the average from tests made by Parker and Yates (*The Philippine Journal of Science*, Vol. XII, A, No. 2, March, 1917).

Accepting this figure as substantially correct for kernel produced at the Atwabo Plantation, the average moisture content of the forty-seven lots referred to would be 5.87%.

Records of the occurrence of mould on the copra in forty-one of these lots were carefully kept. The lots were stored with other copra in the copra store; they were examined periodically and the presence of mouldy copra noted, the mouldy copra being weighed and separated from the clean copra. The records are shown in Table I.

TABLE I.

RATE OF DRYING OF COPRA.

Initial Weight of Fresh Kernel was 100 *lbs. in each case.*

Lot No.	Initial Dry Weight. lbs.	Number of Days taken to become 100% mouldy.	Weight at End of Experiment. lbs.	Lot No.	Initial Dry Weight. lbs.	Number of Days taken to become 100% mouldy.	Weight at End of Experiment. lbs.
1	59½	57	60½	22	56½	66	60½
2	61	40	60½*	23	55½	48	59½
3	59	47	57½*	24	56½	67	59½
4	58½	57	58¾	25	55	67	58½
5	58	54	59½	26	57½	69	60½
6	60	36	60	27	55½	56	58½
7	56	73	58½	28	57	75	60½
8	57	52	60½	29	56	77	58½
9	57	80	59½	30	59½	64	60½
10	57	63	57½	31	61½	58	63½
11	55½	46	55½	32	58	90	59
12	59	51	60	33	60	77	61
13	57¾	66	59¼	34	61	78	61†
14	57¼	62	59¼	35	56	64	57†
15	59½	62	58¼*	36	63½	86	64
16	55	59	58¼	37	61	120	61
17	54½	77	58½	38	66	187	67
18	53½	74	57½	39	56	152	57½
19	54	56	57½	40	57	148	55½†
20	55	70	58½	41	56½	129	56½
21	54½	70	57½				

* Some taken out for moisture tests.
† Became weevilly.

It will be noted that the time taken to become 100% mouldy varied from thirty-six days—probably an extreme case—to 187 days. It has yet to be determined whether copra dried and stored in the wet months is more liable to attack by mould than that dried and stored in the drier months. Since, however, in every case the moulds occurring were those which exist with a very small percentage of moisture, it is probable that, once the copra is initially well dried, the season in which it is dried and stored would have little influence on the occurrence of moulds on it.

It should be noted that in no case did a pernicious mould occur. In every case the mould was merely a grey-green superficial mould, of the kind regarded by Parker and Yates as harmless, and, when occurring by itself, indicating a well-dried copra.

Four lots, Nos. 2, 3, 15 and 40, showed a decrease in weight at the end of the experiment. This is accounted for by some copra having been removed for moisture determinations and weevil attack.

Five lots, Nos. 6, 11, 34, 37 and 41, showed no change in weight, probably due to the same causes.

Thirty-two lots showed an increase in weight at the end of the experiment, ranging from ¼ lb. in Lot 4 to 4 lbs. each in Lots 17, 18, 22 and 23. The increase in weight in these thirty-two lots was 73 lbs., or 3.98%.

At the commencement of investigations in copra at the Atwabo Plantation it was thought that stored copra would take up sufficient moisture to enable pernicious moulds to grow on it. Though stored copra does undoubtedly take up moisture, as is shown by the increase in weight of the thirty-two lots dealt with in the preceding part of the paper, it is clear that it does not take up sufficient moisture to enable pernicious moulds to grow on it.

With a view to determining the increase in weight of stored copra by the absorption of moisture, and also its condition after lengthy storage, four bags, each containing 100 lbs. of carefully dried copra, were set aside for periodical weighing and inspection. These bags were stored with other copra in the copra store. The records for each bag are shown in Table II.

A further bag, containing 57 lbs. copra, resulting from 100 lbs. kernel which had been treated with sulphur dioxide and sun-dried, was put up on May 7th, 1929, for observation and periodic weighing. The records are shown in Table III.

TABLE II.

Moisture Changes in Stored Copra.

Bag. No. 1.			Bag No. 2.		
Date. 1929.	Weight. lbs.	Remarks.	Date. 1929.	Weight. lbs.	Remarks.
May 9	100	Kiln-dried	May 9	100	Kiln-dried.
May 31	104		May 31	103	
June 15	104½		June 15	104½	
July 3	105		July 3	105	
July 19	105		July 19	104	
Aug. 2	104		Aug. 2	103½	
Aug. 17	104		Aug. 17	103½	
Sept. 7	103	In fair condition	Sept. 7	102½	Slightly mouldy, some weevils.
Sept. 16	103	Getting weevilly	Sept. 16	102½	
Oct. 2	103	Some superficial mould	Oct. 2	102½	
Oct. 17	102		Oct. 17	101½	
Nov. 4	101¼		Nov. 4	100¾	Superficial mould, weevilly.
Nov. 16	101		Nov. 16	100½	
Dec. 13	101		Dec. 13	100½	
Dec. 30	100¾	Weevilly, superficial mould	Dec. 30	100	Superficial mould, weevilly.

Bag No. 3.			Bag No. 4.		
May 9	100	Kernel treated with sulphur dioxide and sun-dried	May 9	100	Kernel treated with sulphur dioxide and sun-dried.
May 31	103½		May 31	103	
June 15	104½		June 15	104½	
July 3	104½		July 3	104	
July 19	104		July 19	103	
Aug. 2	104		Aug. 2	102½	
Aug. 17	104	In good condition	Aug. 17	103	
Sept. 7	102½		Sept. 7	102	In good condition, a few weevils.
Sept. 16	102½	Slightly weevilly	Sept. 16	102	
Oct. 2	102½	Weevilly and slightly mouldy, otherwise in good contion	Oct. 2	101	Weevilly, and very slightly mouldy.
Oct. 17	101½		Oct. 17	101½	
Nov. 4	100¾		Nov. 4	100¾	Mouldy and weevil.
Nov. 16	100		Nov. 16	100	
Dec. 13	100	In better condition than 1 and 2	Dec. 13	100	
Dec. 30	99½		Dec. 30	99	In better condition than 1 and 2.

TABLE III.

MOISTURE CHANGES IN STORED COPRA.*

Date. 1929.	Weight. lbs.	Date. 1929.	Weight. lbs.	Date. 1929.	Weight. lbs.
May 7 ..	57	Aug. 2 ..	59	Oct. 17 ..	58
May 31 ..	59	Aug. 17 ..	59	Nov. 4 ..	57½
June 15 ..	59½	Sept. 7 ..	58½	Nov. 16 ..	57¼
July 3 ..	59½	Sept. 16 ..	58½	Dec. 13 ..	57½
July 19 ..	60	Oct. 2 ..	58½	Dec. 30 ..	57

It will be seen that in each case a notable increase in weight is recorded during June and July, the wet months, and that, commencing with August, the weight afterwards decreased, and in two cases came back to the original weight by the end of the year. In one case the weight at the end of the year was slightly above the original, and in two cases less.

In no case did pernicious moulds occur. The mould that did occur was a grey-green superficial one. The copra, in each case, was in fairly good condition after the eight months' storage.

(NOTE.—This experiment was carried on till July 18th, 1930, or a period of sixty-two weeks. At that time the copra was very weevilly, but no bad moulds were present.)

CONCLUSIONS.

The experiments described show that :—

(1) Well-dried copra, that is, copra containing not more than 6% of moisture at the time it is stored, can be safely stored for lengthy periods.

(2) A growth of superficial grey-green mould will occur on it. This mould may be regarded as harmless.

(3) Pernicious moulds, i.e., black and brown moulds, will not occur on it.

(4) Such copra takes up moisture and increases in weight during storage, but not in sufficient quantity to permit of the growth of pernicious moulds on it.

* Kernel sulphured and sun-dried.

(5) The absorption of water is seasonal, that is, during wet weather copra will take up moisture and during dry weather it will part with it. In other words, it maintains a moisture-equilibrium with the atmosphere.

(6) For plantation purposes it may be taken that copra may be safely stored, and will not be attacked by pernicious moulds, if its weight at time of storing does not exceed 58% of the weight of the original kernel.

PAPER No. XXXI.

A SUMMARY OF THE YIELDS AT THE ANAJI AND ODUMASE OIL-PALM EXPERIMENT STATIONS.

By T. LLOYD WILLIAMS.

Oil-palm breeding and general experimental work is now concentrated at two stations, Anaji in the Western Province and Odumase in the Eastern Province. These stations are representative of the conditions in the western and eastern portions of the oil-palm belt respectively.

DESCRIPTION OF TRIALS.

These stations were established in 1924. In both cases stands of natural oil-palm bush were taken as a starting-point and part of the area cleared of all growth except palms. The uncleared portions were each divided into two plots, the fruit from the first plot being harvested with as little disturbance to the plot as possible and that from the second plot being untouched.

The areas of the various plots at the two stations are as follows :—

Anaji.	Plot A.	Cleared	50 acres.
,,	Plots B and D.	Not cleared	40 acres (each 20 acres).
,,	Plot C.	Not harvested ..	20 acres.
Odumase.	Plot A.	Cleared	10 acres.
,,	Plot B.	Not cleared ..	5 acres.
,,	Plot C.	Not harvested ,,	5 acres.

In the cleared plots the palms are being thinned to approximately 70 per acre—gaps being filled with seedlings—and receive a rough cultivation.

DISTRIBUTION OF PALMS.

The number of trees and their distribution is at present as follows :—

Anaji.—From five 1-acre sample plots chosen in different parts of the plot the distribution is as follows :—

Height Class.	*No. per Acre.*
Seedlings	93.0
Fruiting trees up to 6 feet high	30.8
Trees 6 to 12 feet high	25.0
Trees 12 to 18 feet high	13.8
Trees above 18 feet	8.0
Number of trees (mean per acre)	77.6

Odumase.—The distribution of trees in the cleared plot is :—

Height Class.	*No. per Acre.*
Seedlings	34.6
Fruiting trees up to 6 feet high	29.9
Trees 6 to 12 feet high	29.8
Trees 12 to 18 feet high	13.4
Trees above 18 feet high	7.9
Number of trees (mean per acre)	81.0

VARIETIES OF OIL-PALM ON THE STATIONS.

The varieties commonly grown in this country are described by Auchinleck (1) and Howes (2). It has been found convenient to retain the native classification. This depends on colour and shell thickness.

The main types may be briefly described as follows :—

(*a*) **Thick-shelled Types.**—Here there are three main types, Abepa, Abetuntum and Abedam. The first two are very similar, and many intermediate types have been found. The fruit is black when young, and on maturity dark red in the upper region and light red basally, the proportions of dark and light red being said to distinguish the varieties.

In Abedam the fruit is green when young and brick red when ripe. In all these varieties shell thickness varies greatly.

(*b*) **Thin-shelled varieties**, called Abobobe or Adibe, have the same colour types as above, and are known as Abedam-Abobobe, etc. Here again the shell thickness varies, and many palms have fruit intermediate between (*a*) and (*b*).

(*c*) **Abehene.**—The " king " palm is very rare. It is probably only a teratological form.

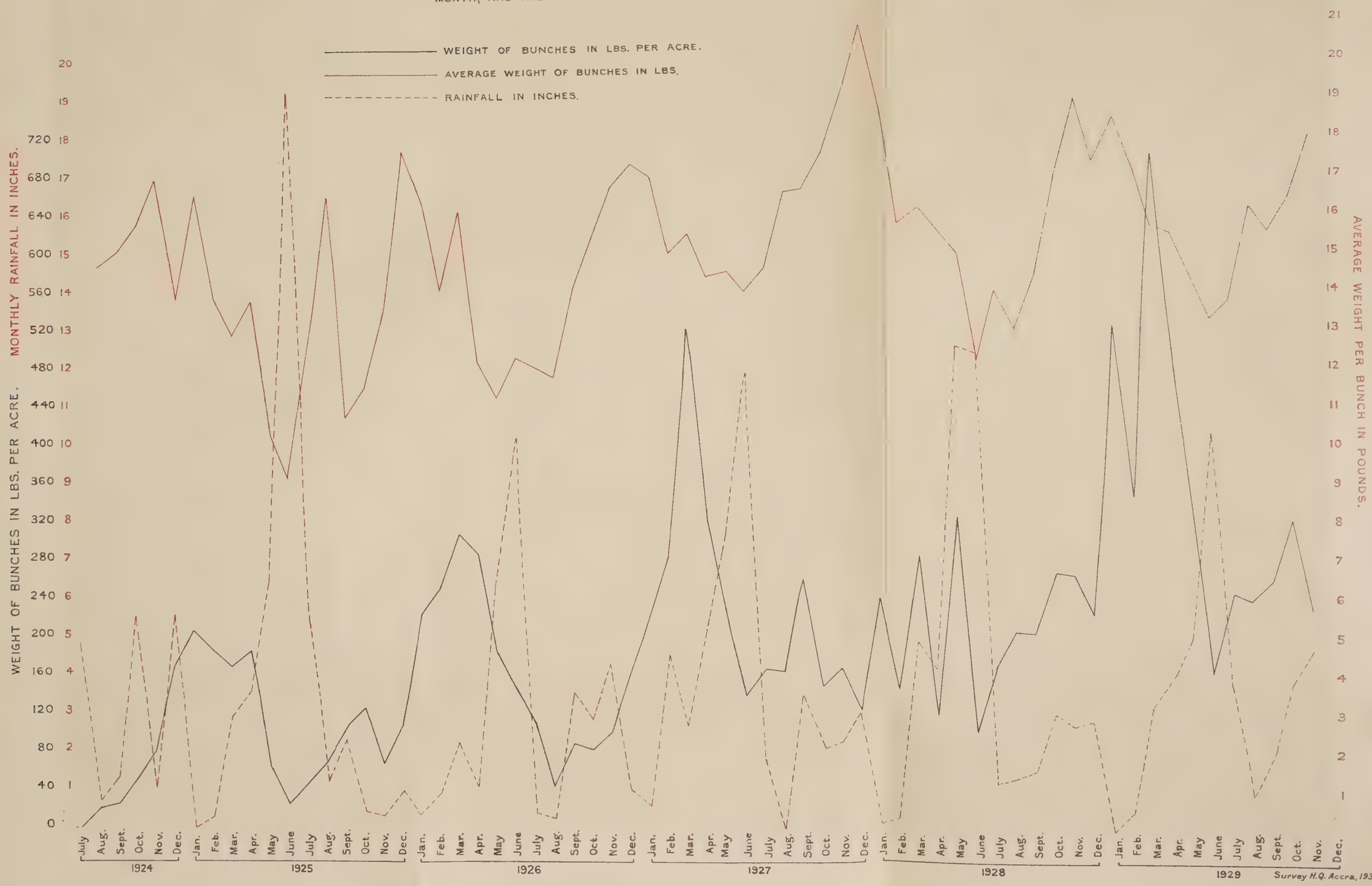
Several palms of the above types have been found with this character, but so far no " king " palm with mantled fruit has been recorded from the Gold Coast.

(*d*) **Diwakkawakka, or Klode (Ewe).**—The mantled form is rare. No trees of this type have been reported in the Western or Central Provinces and only very few in the Eastern.

Plate I.

ANAJI (CULTIVATED PLOT OF OIL PALMS)

TOTAL WEIGHT OF BUNCHES PER ACRE PER MONTH, AND AVERAGE WEIGHT PER BUNCH PER MONTH.



Survey H.Q. Accra, 1930.

YIELDS RECORDED.

The following yield figures are recorded on these stations :—

Bulk Yields on All Plots.—At Odumase these are subdivided into the different varieties.

Individual Yields.—Sixty trees have been individually recorded at Odumase since 1924 and twenty at Anaji. The number of trees individually recorded was increased considerably in 1928 in connection with the breeding work in hand.

At Odumase all the trees in Plot A are divided into different height classes (0 to 6 feet, 6 to 12 feet, 12 to 18 feet, and above 18 feet), and the yields recorded separately. At Anaji the record is taken for fifty trees in each height class.

The yields per acre for the various plots are given in Tables I and II.

TABLE I.

PLOT A. CULTIVATED. ANAJI.

Year.	No. of Bunches per Acre.	Weight of Bunches per Acre. lbs.	Average Weight of Bunches. lbs.
1924 (6 months) ..	25	374	15.0
1925	109	1,434	13.2
1926	147	2,041	13.9
1927	176	2,806	15.9
1928	167	2,630	15.7
1929 (11 months) ..	245	3,907	15.9
Average, 5½ years ..	158	2,398	15.2

TABLE II.

PLOT D. UNCLEARED. ANAJI.

Year.	No. of Bunches per Acre.	Weight of Bunches per Acre. lbs.	Average Weight of Bunches. lbs.
1924 (6 months) ..	8	114	14.2
1925	69	795	11.5
1926	39	395	10.3
1927	42	480	11.4
1928	17	213	12.5
1929 (11 months) ..	43	545	12.6
Average, 5½ years ..	32	462	11.7

The monthly variation in yield for the cultivated plot is shown in Plate I. On this graph the variation in the average weight per bunch and the monthly rainfall for Sekondi (6 miles) are also shown. In Plate II the percentage yield per month for a period of five years is shown. In Plate III (fig. 1) the annual yield per acre for Plots A and D are shown. In Plate III (fig. 2) the percentage yield per month and the average monthly rainfall, both over a period of five years, are shown.

The bulk yield figures at Odumase vary in a most extraordinary manner, and it is not proposed to publish them until they are still further checked.

DISCUSSION OF FIGURES OF YIELD.

The yield per acre for the cultivated plot as a percentage of the uncultivated plot is given in Table III.

TABLE III.

Year.	Percentage of Plot D. (Yield per Acre).
1924 (6 months) ..	326
1925	180
1926	512
1927	585
1928	1,235
1929	717
Average 5½ years ..	519

Superficially it would appear that the gain due to clearing and cultivation averages 519%. However, whilst there is an undoubted gain, it is not nearly as great as this, for in a 20-acre plot, with very thick bush surrounding the palms, the difficulties of collection are very great and also adequate supervision is difficult. This is well shown by the figures for the six months of 1924, when the cultivated plot was being cleared. The plots under consideration adjoin one another and are very similar in their oil-palm population, yet whilst one plot was being cleared, and before the yield could be greatly influenced by clearing or cultivation, it gave a yield 326% greater than the uncleared plot. This tends to prove that increased facilities for collection and increased ease of supervision are some of the main determining factors causing the increased yields in Plot A. Plate III (fig. 1) shows, however, that the yield per annum on Plot A is steadily

PLATE II.

OIL PALM YIELDS . ANAJI.

PERCENTAGE PER MONTH OF THE ANNUAL YIELD

(5 YEARS AVERAGE)

Survey H · Q . Accra 1930

ANAJI . OIL PALM PLOTS

FIG. I. ANNUAL YIELD, CULTIVATED AND UNCULTIVATED PLOTS.

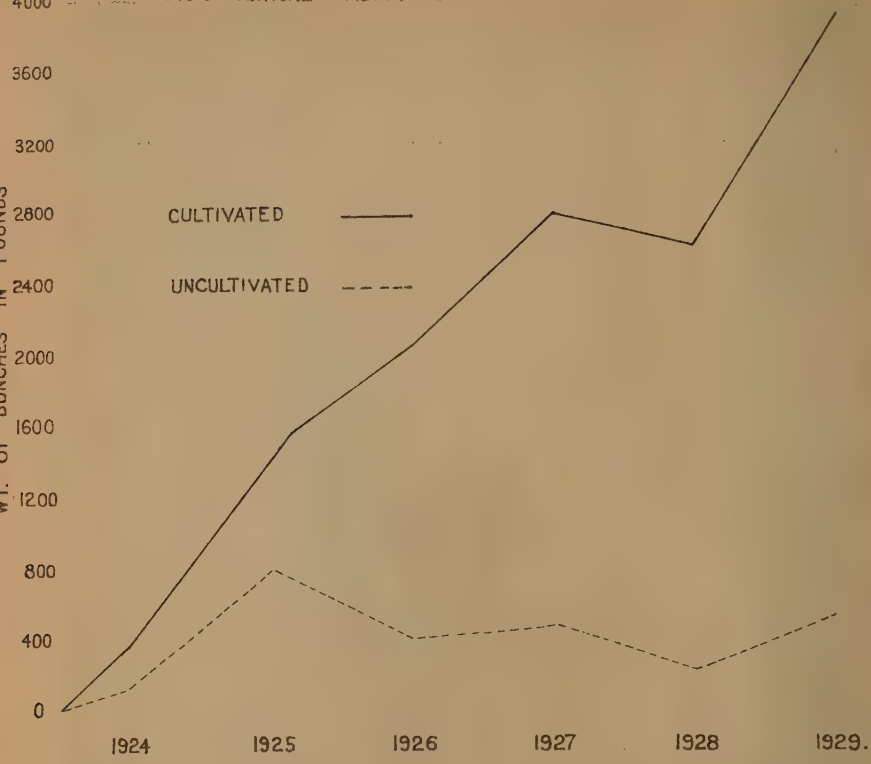
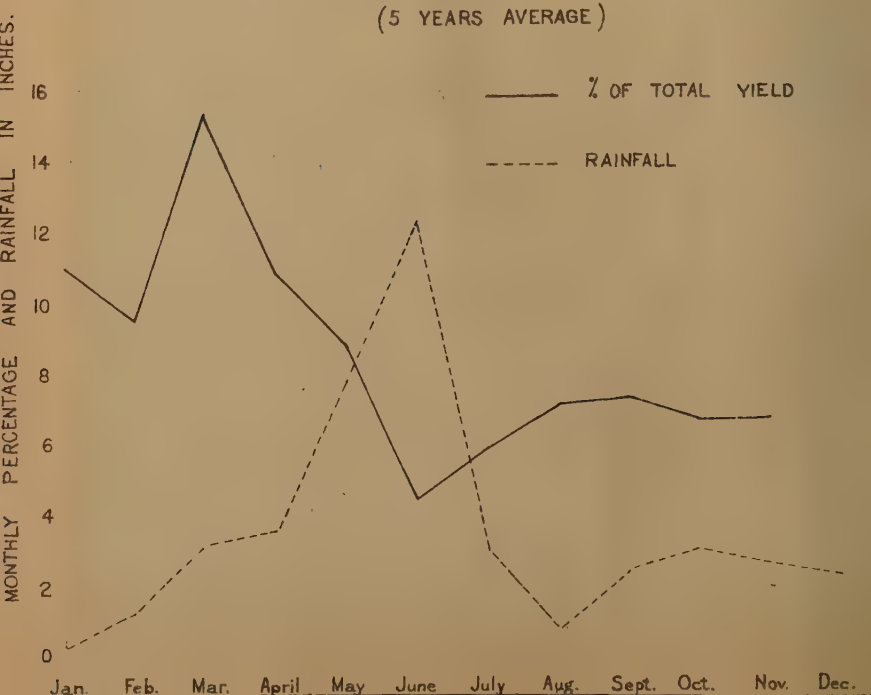


FIG 2. PERCENTAGE PER MONTH OF TOTAL YIELD AND MONTHLY RAINFALL.

(5 YEARS AVERAGE)



rising, while Plot D has no significant increase in yield. The rise can undoubtedly be attributed to clearing and cultivation.

AVERAGE WEIGHT PER BUNCH.

The average weight per bunch has also been steadily increasing in Plot A, whereas in Plot D it has only increased slightly. Leaving out of consideration the figures for 1924, when there were several disturbing factors, the average weight per bunch in Plot A has increased from 13.2 lbs. in 1925 to 15.9 in 1929, whilst in Plot D the weight per bunch has increased only from 11.5 to 12.6—this small increase being due, possibly, to the limited clearing necessary for harvesting.

At Odumase Oil-palm Plantation a most definite increase is also found. Thus clearing and cultivation increase the average weight per bunch.

The production of fruit is without exception greatest during the months January to May, with a decided tendency to the greatest production in March—which month, on the five years' average, is 15.4%, whilst in the four months, January to April, 47% of the annual yield is produced. The percentage production figures published by Paterson (3) for Pechi Blengo, in the Trans-Volta district of the Eastern Province, are very similar to these figures (*see* Plate II).

The minimum production of fruit is, without exception, in June.

The minimum weight per bunch occurs at approximately the same period as the minimum production.

There is a definite tendency for a lag to occur between the months of highest yield per acre and the months of greatest weight per bunch, the latter occurring in October–January. This is contrary to the finding of Rutgers (8) in the Dutch East Indies, where the month of highest production is the month of highest weight per bunch.

RELATION OF YIELD TO RAINFALL.

The length of time between fertilisation and ripening has been recorded in connection with breeding-work for forty-two bunches on thirty-three trees. When grouped into class intervals of five days the mean is 149.9 days with a standard deviation of 2.06. There is great variation in the length of time of ripening, and it is thought probable that the length of time between fertilisation and ripening varies with the season, being longer in the wet season. The maximum setting of fruit occurs from July to September, i.e., when the wet

season is well established. Rutgers (8) explains this as follows: "The development of the young inflorescences is retarded during the dry season, and hence, when the wet season arrives, a greater number of flowers will form, also the ripening of these bunches is accelerated in the following dry season." It is considered that possibly one of the reasons that the maximum production is found in March, i.e., fruit set when the rains are finishing, is that in May and June the high rainfall hinders pollination. This point is being investigated.

INDIVIDUAL YIELDS.

(*a*) **Anaji.**—Twenty trees of different varieties, chosen at random, have been individually recorded since 1924, and the yields of the five highest and five lowest yielding trees are given in Table IV.

TABLE IV.

INDIVIDUAL YIELD RECORDS. ANAJI (RECORDED FOR 5½ YEARS).

No. of Tree.	Variety.	No. of Bunches per annum.	Weight of Bunches per annum. lbs.	Average Weight of Bunch. lbs.
5	Abetuntum ..	8.4	128.0	14.4
2	Abepa	4.2	96.2	22.8
3	Abepa	4.0	93.1	23.3
2	Abedam ..	5.5	91.6	16.5
4	Abetuntum ..	5.8	89.8	15.5
1	Abepa	3.1	43.8	14.0
4	Abepa	2.0	33.8	16.9
4	Abedam ..	2.9	27.3	9.4
3	Abefita	2.3	22.9	17.2
1	Abedam ..	2.2	20.0	9.0

In 1928 many more trees were individually recorded in connection with breeding-work, special attention being paid to thin-shelled types. The previous yields of trees of this type had been disappointing, the best tree at Anaji giving a yearly yield of only 42.2 lbs. (bunches).

Table V gives the annual yields of some of the specially selected trees. The great increase over the above figures, especially as regards thin-shelled types, will be noted.

TABLE V.

ANAJI. INDIVIDUAL YIELD RECORDS. (RECORDED FOR SIXTEEN MONTHS).

No. of Tree.	Variety.	No. of Bunches per annum.	Weight of Bunches per annum. lbs.	Weight of Fruit per annum. lbs.	Average Weight of Bunch. lbs.	Fruit as % of Bunch.
A.D. 10	Adibe	11.2	229.5	131.2	20.4	57.2
A.D. 8	Adibe	5.2	198.0	127.5	37.7	64.2
A.D. 14	Adibe	6.7	177.7	90.0	26.3	50.6
A.D. 5	Adibe	9.0	122.2	78.2	13.7	61.9
A.D. 6	Adibe	3.7	78.7	42.7	21.0	54.3
A.D. 11	Adibe	3.0	37.5	24.2	12.5	62.0
L. 7	Abetuntum ..	5.2	228.7	133.5	43.6	58.4
L. 2	Abepa	4.5	210.0	146.2	46.7	69.6
L. 8	Abetuntum ..	5.2	141.3	97.5	27.0	68.8
L. 17	Abedam ..	6.0	65.2	44.2	10.9	67.8
L. 24	Abepa	1.5	33.0	18.7	22.0	56.8

(*b*) **Odumase.**—Individual yield records of twenty trees of each of the common thick-shelled varieties have been kept since 1924. These trees were chosen at random and should indicate any considerable difference between the yields of the three varieties. The mean total yields over five years are as follows :—

TABLE VA.

MEAN YIELD PER PALM PER ANNUM (RECORDED OVER FIVE YEARS).

Variety.	Weight of Bunches in lbs.
Abepa	84 9
Abetuntum	88.4
Abedam	94.1

These figures have been examined statistically and the difference is not significant, P being approximately 0.8.

Great individual variations are to be expected, and in Table VI the yields of the five highest and the five lowest yielding trees are given.

TABLE VI.

INDIVIDUAL YIELD RECORDS. ODUMASE. (RECORDED OVER FIVE YEARS).

No. of Tree.	Variety.	No. of Bunches per annum.	Weight of Bunches per annum. lbs.	Average Weight of Bunch. lbs.	Fruit as % of Bunch.
1	Abepa	17.7	197.5	25.3	61.2
14	Abetuntum ..	8.0	186.0	23.3	59.1
20	Abetuntum ..	9.5	171.1	18.1	48.5
8	Abedam'.. ..	7.4	170.0	23.2	45.1
7	Abedam	7.2	153.2	21.4	48.8
6	Abepa	4.7	44.8	9.7	46.6
2	Abetuntum ..	4.0	43.0	12.0	49.5
20	Abepa	4.0	41.8	11.6	58.0
13	Abetuntum ..	2.9	40.9	13.9	66.3
11	Abedam	2.9	38.1	12.9	54.5

There is a very great difference in yielding capacity between individual trees—the extremes at Odumase being 120.8 lbs. of fruit as against 20.7 lbs. These figures emphasise the importance of selection and breeding high yielding types of oil-palms.

The yields at Odumase have been generally higher than at Anaji. This is borne out by the average weight per bunch figures for the bulk yields. These were, in 1929, 19.1 lbs., as against 15.1 at Anaji.

There is great variation in average weight per bunch, from 46.7 lbs. to 9 lbs., and in the number of bunches per annum, thus showing the numerous combinations by which a high yield can be obtained.

INFLUENCE OF AGE ON YIELD.

Table VII gives the yields of fifty trees in each height class at Anaji for 1929.

TABLE VII.

YEARLY YIELDS IN LBS. FOR FIFTY TREES IN EACH CLASS.

	Young Palms 0 ft. to 6 ft. high.	Medium Palms 6 ft. to 18 ft. high.	Tall Palms above 18 ft. high.
No. of bunches	93	97	66
Wt. of bunches	1,108	1,998	1,476
Average wt. per bunch ..	11.9	20.6	22.4

It will be seen that the young palms give a large number of bunches, each of which is comparatively small, and that as the palms grow older the weight per bunch increases and the number decreases, the period from 6 to 18 feet yielding the maximum. The length of time covered by this period and the age at which the maximum yield can be expected are now under investigation.

COMPARISON OF ABOVE YIELDS WITH OTHER PUBLISHED RECORDS.

Waters (5) gives the average yield for palms in full bearing in Sumatra as 1,400 lbs. of pericarp oil. The above yields may be converted to the same basis as follows : It has been found from bulk records on the above stations that the average percentage of fruit per bunch is 58.2, and as the average percentage of pericarp oil is probably about 20%—certainly not much higher—therefore the average yield at Anaji is 279 lbs. of pericarp oil and the yield for 1929 is 445 lbs. of pericarp oil per acre.

Smith (6) gives an average yield for four plots of thick-shelled palms at Calabar of 987 lbs. of pericarp oil per acre (oil extraction of 90% efficiency). This plantation is approximately eighteen years old.

Deighton (7) gives a yield of 3,159 lbs. of fruit for a plantation eight years old, which, assuming 20% of pericarp oil, gives a yield of 632 lbs. of pericarp oil per acre.

In comparing the above yields with those from the Gold Coast, it must be taken into consideration that the former figures refer to palms of uniform age planted on a definite system and that have been under cultivation from the time of planting, whilst the Gold Coast figures refer to blocks of palms of all sizes and ages that have been cleared from the natural bush.

The best trees so far selected at Anaji give yields similar to these given by Smith (6) for the best trees at Calabar. Both of these, however, fall far short of some of the individual yields obtained in the East Indies.

SUMMARY.

1. The bulk yields at Anaji are discussed, and it is shown that :—

(*a*) There is a definite increase in yield on the cultivated plot, but that the increase is not as great as the figures appear to indicate, owing to the difficulties of collection and supervision on the uncultivated plots.

(*b*) The average weight per bunch has increased on the cultivated plots.

(*c*) 47% of the annual yield is produced in the four months, January–April.

(*d*) The month of lowest production is June.

(*e*) The relation of weight per bunch to the monthly production of fruit, and the relation of rainfall to yield, are discussed.

2. Individual yields of trees at Anaji and Odumase are discussed.

3. It is shown that with increasing age the number of bunches per tree decreases and the weight per bunch increases.

4. A comparison with yields of oil-palm in other countries is made.

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OIL PALM AREA, APAM DISTRICT, CENTRAL PROVINCE.

PAPER No. XXXII.

SURVEY OF THE OIL-PALM AREA OF APPAM, CENTRAL PROVINCE.

By W. R. HUDSON.

A survey of this area was made by the writer in June, 1928, and by Mr. J. S. Martinson the following August, the reports of these surveys being summarised by Mr. A. C. Miles, Officer-in-Charge, Division of Statistics and Surveys of the Department. This paper has been compiled from available data and indicates the possibility of re-establishing the palm-oil industry in the Appam district and the potential wealth of the area from the possible development of the industry on modern lines.

Locality.

The area referred to is the more or less rectangular stretch of country running about 6 miles north of the littoral from Appam, bounded on the North by the Swedru-Ajumaku road, on the East by the Swedru-Winneba road and on the West by the Biseasi-Salt-pond road. Although a rich natural growth of oil-palms covers the major part of this area, the central portion contains a belt where the palms are at their greatest density and the approximate location of this belt is shown on the attached map. The palms that exist outside this belt can be considered as being too widely spaced to be economic for fruit collection on a commercial scale ; the exception to this being the area extending North in the vicinity of Abodum, where it fringes the cacao growing area, and where, in consequence, there would be little chance of success with the palm industry.

Extent of Belt.

The dense belt is some 105 square miles in extent, and it is estimated that approximately 25% of this is occupied by village sites, food crop areas, roads and waterways. Thus, roughly, there are 50,000 acres of actual palm land suitable for commercial development.

Density of Palms.

It was not possible to make a census of palms over the whole area, but counts were made on measured plots of 1 acre each in sections, through sparse and densely established areas throughout

the belt, several plots being chosen at random in the various sections. The following table shows the results obtained :—

Measured Acre Plot.	Total established Trees per Acre, over three years old.	Old (generally to be considered as fruiting).	Young (generally to be considered as non-fruiting).
Dense Section A Plot 1	128	89	39
,, ,, A ,, 2	140	92	48
,, ,, B ,, 1	123	97	26
,, ,, C ,, 1	130	85	45
,, ,, C ,, 2	115	79	36
Medium Section A Plot 1 ..	98	78	20
,, ,, A ,, 2 ..	121	76	45
,, ,, B ,, 1 ..	107	63	44
,, ,, B ,, 2 ..	99	58	41
,, ,, C ,, 1 ..	87	70	17
Sparse Section A Plot 1 ..	73	44	29
,, ,, B ,, 1 ..	71	64	7
,, ,, B ,, 2 ..	76	41	35
,, ,, C ,, 1 ..	81	54	27
,, ,, C ,, 2 ..	92	69	23
Means	103	71	32

The counts varied from 71 to 140 palms of all grades over three years old, the average working out at about 103, of which approximately 70% can be regarded as productive. The total number of established palms is thus estimated at 5,150,000, with a total of 3,500,000 in bearing.

Estimated Yields.

From the above estimate of stand per acre an average yield of 1 ton of fruit bunches per acre could be expected, and, assuming the weight of clean fruit to be 50% of the bunches and that 20% of the weight of clean fruit is recoverable as pericarp oil, the estimated oil yield is 2 cwts. per acre from 10 cwts. of clean fruit. In addition to this, the clean fruit would yield approximately 8% of kernels, which would amount to 90 lbs. per acre. Thus the total oil and kernel yields for the whole area of 50,000 acres is estimated at 5,000 and 2,000 tons per annum respectively.

Population.

There are some sixty-five villages within the belt, with populations ranging from 80 to 1,600 ; the total population, according to the 1921 Census return, being 16,600. A census of some of the villages in the area, taken in 1928 by the Political Department, showed an increase of about 22% in the period of seven years.

Roads.

The district is fairly well supplied with roads, partcularly in the eastern portion of the belt, which is directly North of and connected by road to Appam. The latter place could, therefore, be considered as a potential port for shipping purposes. Some of the roads would be impassable for motor traffic during the heavy rains, but during the dry season, which fortunately coincides with the main cropping period, they would all be generally fit for lorry traffic.

Rainfall.

No figures exist of rainfall in the actual locality, but it is probably slightly in excess of the following figures given for Saltpond and Winneba, as the belt lies about 12 miles inland between these two towns.

Month.	Saltpond. Mean over 10 years.	Winneba. Mean over 7 years.
January	0.45	0.58
February	0.43	0.44
March	2.47	1.55
April	3.28	2.83
May	6.88	6.43
June	8.00	6.01
July	2.53	2.13
August	0.82	1.36
September	1.67	1.40
October	2.69	1.96
November	2.01	1.70
December	0.99	0.32
Total	32.30	27.91

Past History of the District.

Many years ago quite an appreciable native industry existed in the district, and the port of Appam exported a considerable amount of palm oil and kernels. Only crude and wasteful methods of extraction were used, and the only form of cultivation of the palms carried out was the clearing of a small space around each palm; the latter only to facilitate the collection of fruit. With the advent of cacao, however, which proved much more remunerative to the native, the industry gradually declined in the face of this competition, and a great number of the people moved North from the district to the cacao-growing areas. Nothing whatever is done in the district now beyond the collection of fruit for local needs, and it is some twelve years since the port of Appam became a sufferance wharf.

Potentialities of the District.

It will be seen from the foregoing that the area under discussion possesses considerable potential wealth and natural facilities for development. Palms are abundant, ample labour is available, an adequate road system and water supply exist, and the district is close to the port of Appam. Furthermore, the chiefs and people concerned are very keen to start an industry.

Considering the possible effects upon the Gold Coast resultant from over-production of cacao, and in view of the increasing world's demand for edible fats and oils, a revival of the palm industry becomes more and more desirable. It is obvious, however, in view of the demand by manufacturers for an oil of standard purity and the increasing competition in the East, where the industry is being highly organised, that there is little hope of re-establishing the industry as a purely native one. Plantations in the East, with their scientific methods of preparation, can produce oil with as little as 2% to 3% of free fatty acid. Crudely extracted oil usually has a very high acidity and is used chiefly for technical purposes. There is little likelihood of an increased demand for oil for such purposes. The only possibility, therefore, appears to be development by means of central mills, using modern scientific methods of oil extraction, kernel separation and utilisation of waste products. The erection of such mills, however, involves considerable capital outlay, and would obviously be unsound without some form of guarantee of adequate supplies of fruit. The economics of the problem here are also affected by the scientific development of plantation in the East, where seed selection is carried out with a view to obtaining maximum yield per acre. It cannot be hoped, of course, to produce anything like the yields obtained in the East, but it has been proved on the Government oil-palm plantations that natural palm bush responds very well to ordinary rough cultivation methods, and, therefore, such cultivation of the area under discussion would obviously be most necessary.

Labour.

Providing some means existed of ensuring regular work, the population could be considered as ample to provide the necessary labour for collection of fruit for a mill.

Mill Site.

Since it is probable that the only practical way of resuscitating the industry in the district is by the erection of a modern mill, it is necessary to view the facilities offered for a suitable site. This should be more or less central as regards location and road system, and, above all, should be within easy reach of an adequate water supply. Regarding the latter, it must be borne in mind that the main crop of palm fruit is harvested during December–March, the dry period, when streams are at their lowest. The only reliable source of water

supply in the district is the River Nakwa or Oche, and this is convenient, inasmuch as it passes through the centre of the belt. Unfortunately, however, it will be seen from the map that the main network of roads is in the portion East of the river, but a suitable centre could probably be made either at the village of Abiadi, which is on the river, or midway between the river and the village of Akropong.

PAPER No. XXXIII.

THE HISPID LEAF-MINER (Coelaenomenodera Elaeidis, MAUL.) OF OIL-PALMS (Elaeis Guineensis, JACQ.) ON THE GOLD COAST.

By G. S. COTTERELL.

Oil-palms in parts of the oil-palm belt in the Gold Coast Colony have suffered at intervals from the attacks of a leaf-mining beetle (Plate I). Specimens of the adult beetle and full-grown larva were sent by Mr. W. H. Patterson, Government Entomologist to the Gold Coast, to the Imperial Bureau of Entomology in 1920. These were determined by Mr. S. Maulik as a new species of the genus *Coelaenomenodera* (family Hispidæ) and described under the specific name *elaeidis* (Bull. Ent. Res., X, p. 171). This species is indigenous to the West Coast of Africa, and hitherto has not been recorded outside the Gold Coast, but no doubt occurs throughout the West Coast oil-palm belt. According to Mr. Maulik, thirty-two species of this genus are known, of which four only are recorded from Africa, the remainder being from Madagascar.

C. elaeidis is similar in habits to *Promecotheca opacicollis* and *P. cumingi*, which occur in Fiji, the Philippines and the New Hebrides, and mine in coconut foliage. The pest was first recorded in the Gold Coast in 1909–10 (Ann. Rept. Agric. Dept., Gold Coast, 1909–10) as defoliating palms in the Eastern Province of the Colony to a large extent. It was stated to have been checked by the advent of the following rainy season. Again in 1919 it was reported as a pest and again as being checked by the following rainy season.

The present attack commenced at the beginning of the rains, i.e., July, and was confined to a small area on the western slopes and top of the Akwapim Ridge in the Eastern Province, a range of hills running N.N.E. from the coast and varying from 800 to 1,500 feet in height. The beetle was also noticed in considerable numbers in a small area on a large oil-palm estate in the Western Province,

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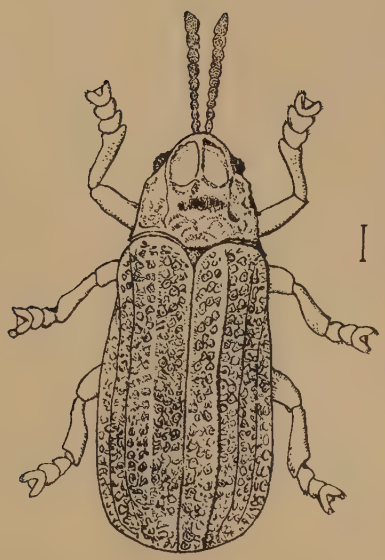
This paper was published in the Bulletin of Entomological Research, Vol. XVI, Part I, in July, 1925, as at that time there was no provision for publication departmentally. It is reprinted here as it is considered that the information should be made available to the Gold Coast public.

The attack in the Eastern Province of the Colony commenced in July, 1923, and lasted until January, 1924. No further attack has occurred in this part of the Colony. Sporadic attacks have occurred since in the Western Province, where there is a large oil-palm concession. It is reported that a reduction in fruiting has resulted.

PLATE I.



COELAENOMENODERA ELAEIDIS, MAULIK.

Survey H.Q. Accra 1930. after Terzi.

PLATE 2.

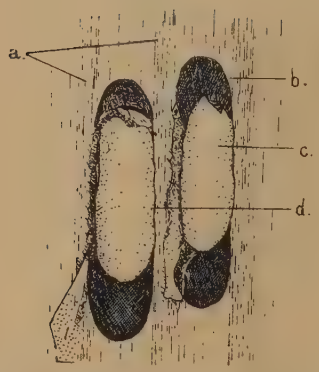


Fig.1. Eggs of *Coelaenomenodera elaeidis, in situ*, after the capsule of fibre and lower epidermis of leaflet have been removed: *a*, leaf-veins; *b*, cavity dug out by female; *c*, egg; *d*, gummy substance attaching egg to side of cavity.

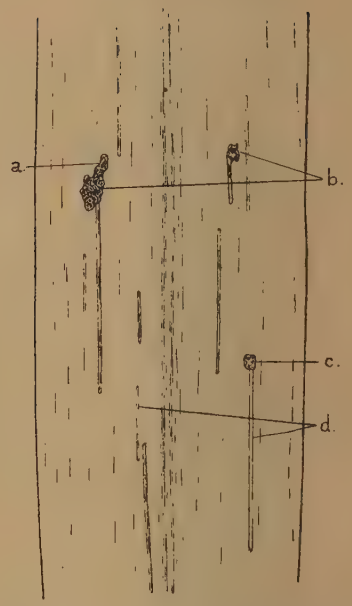


Fig. 2. Egg-masses and feeding channels of adults on lower surface of leaflet: *a*, young larva beginning to mine; *b*, *c*, egg masses; *d*, feeding channels of adults.

Survey H.Q. Accra, 1930.

where the country is more or less flat. This latter attack, however, was soon checked by natural means, and did not cause much damage. The former attack lasted until January, 1924, when it also was checked by natural means.

The oil-palm belt occurs near the coast and extends about 100 miles inland. It is particularly dense in parts of the Eastern Province and in the Western Province. The palm is not cultivated, but the natives collect the fruit from the trees in the forest, bringing them in to extract the oil. However, the cocoa industry, which has flourished remarkably in the last twenty years, has practically supplanted the oil-palm industry, which is only carried on by the natives in a few areas in a very small way. There are a few European concessions in the Western Province, but here again the palm is not cultivated, the fruit being brought into buying centres by the local inhabitants and by labourers employed. Cultivation would hardly be possible, considering the large collecting area and the cost of local labour. This indicates that an artificial control is almost impossible.

Palms of all ages are attacked, except those under three or four years old. The leaflets are attacked soon after they have unfurled, the larvæ mining under the epidermis. As many as ten mines per leaflet have been observed, and these mines may cover a considerable area, depending on the number of larvæ in each mine. Mines have been observed containing five larvæ, which when full-grown have eaten out an area in the parenchyma of the leaflet up to 9 inches long and 1 inch wide. This area turns brown, resembling a large blister. The leaflets are rapidly eaten away and stripped to the midrib by the action of wind, a badly attacked palm having the appearance of the after-effects of fire. This naturally causes a falling off in the yield of palm bunches and devitalisation of the tree. No records are available at present to show to what extent this occurs.

Other food plants of the larvæ are coconuts, *Borassus* and certain ornamental palms. These are not favoured except during a bad attack on surrounding oil-palms, very few larvæ ever maturing, and the life-history is prolonged owing to the coarser food material. The adults feed also on these plants, and, in addition, on royal palms, and in a few cases on elephant grass. The damage caused is not so serious, but is characteristic in that the soft material between the leaf-veins is eaten, giving the appearance of longitudinal cuts along the underside of the leaf. These cuts do not penetrate the leaflet, but as only the upper epidermis is left, the leaflet is considerably weakened and consequently suffers from the effects of wind. They also allow the entrance of fungi, which are naturally prevalent in a humid atmosphere.

The life-history of the beetle was obtained at Aburi Agricultural Station from cages on the trees. Unfortunately other work, mostly of a travelling nature, prevented a regular inspection of these.

The eggs (Plate II, fig. 1) are inserted by the female in the underside of the leaflets, a cavity having previously been dug out to take each egg. They are deposited longitudinally to the leaflet and between adjacent leaf-veins. They are covered by a mass of leaf fibre, which the female regurgitates, having extracted the chlorophyll. From two to five eggs are covered by one egg-mass. Feeding channels of the adult are usually found leading up to the egg-mass, from which the female has collected the necessary fibre (fig. 2).

The egg is creamy white when first deposited and from 2 to 3 mm. in length. It is attached to the leaflet by a gummy substance, which resembles chitin and entirely covers the egg. The incubation period of the egg is approximately twenty-eight days. After hatching, the larvæ commence to mine either up or down the leaflet immediately under the upper epidermis, being found, as a rule, all together at one end of the mine (Plate III, fig. 1). Three moults were the maximum observed. Breeding conditions made it impossible to observe actual moulting, owing to this occurring inside the leaf. Opening up of the leaf caused rapid drying up and consequent death of the younger larvæ. The later larval skins are easily observed inside the mines. The larval life is from forty to forty-four days, depending on climatic conditions. The larva (Plate III, fig. 2) is yellow in colour, legless and flattened, and about 1 cm. in length when full-grown. It has a pair of strong stumpy jaws protruding from the slightly swollen head.

Three to four days before pupation the full-grown larva ceases to feed and locates itself near the middle of the mine. The pupa (Plate III, fig. 4) is dark orange in colour and capable of a small amount of movement in the mine by wriggling its abdomen. The pupal period varies from fifteen to twenty-two days. The adult beetle emerges by a splitting of the anterior end of the pupa and remains in the mine a few hours to harden before eating its way through the dead epidermis of the leaf.

The life-cycle, from the oviposition of the egg to the emergence of the adult, varies from eighty-two to ninety-four days, depending on climatic conditions and the amount of food-material. Copulation and oviposition take place three or four days after emergence, the complete life-cycle being approximately thirteen to fourteen weeks.

The adults feed on the lower surface of the leaflets, usually working in an upward direction. The green material between the veins is eaten, leaving brown longitudinal cuts. In no case was feeding observed on the upper surface of the leaflets. The adults are exceedingly sluggish and do not easily take to flight. On being brushed off the leaves they fall some distance before taking wing. In the early morning and evening they are still more sluggish, falling to the ground when disturbed. Copulation and oviposition take place during the heat of the day.

PLATE 3

Fig.1. Leaf-mines in different stages: *a*, larvae feeding inside mine; b, c, mines.

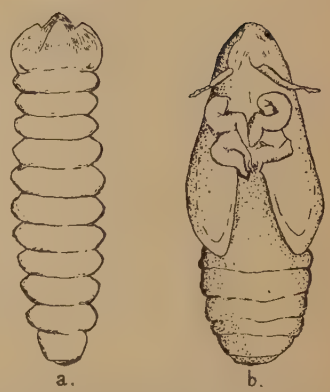
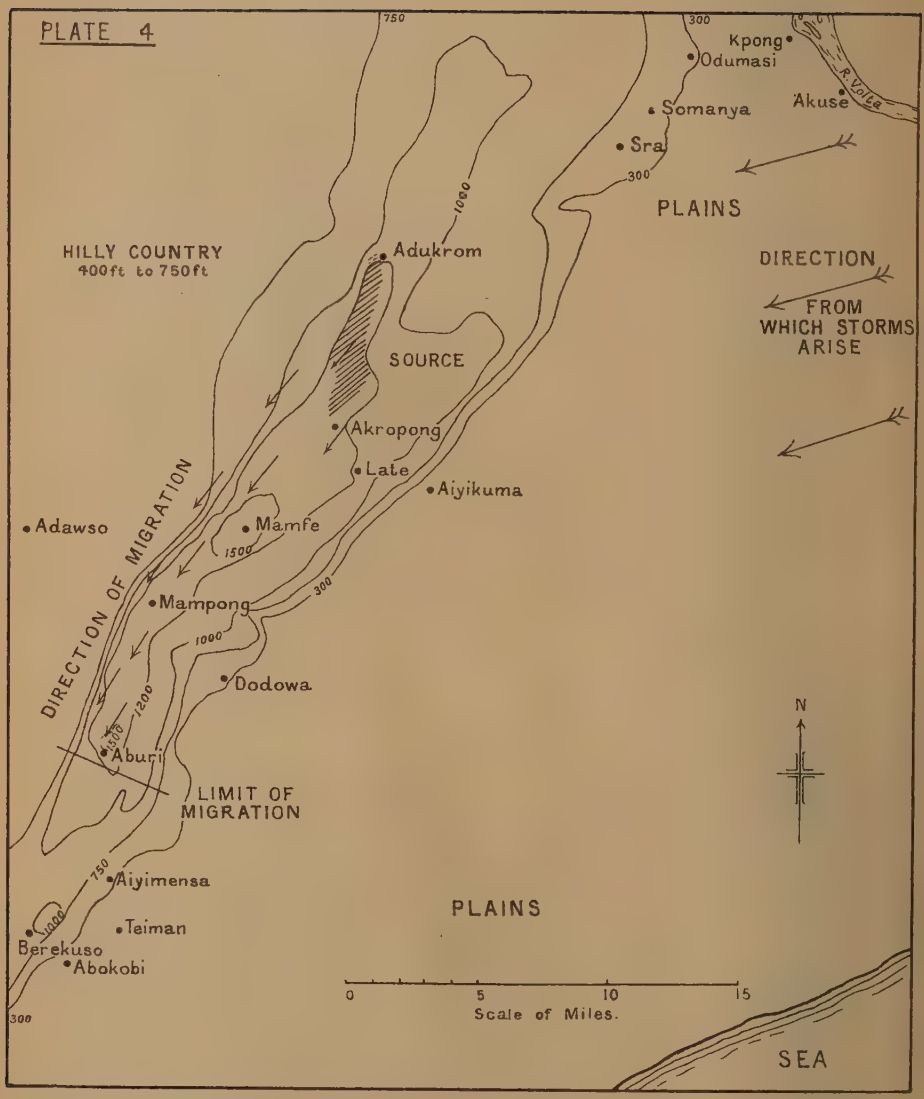


Fig.2. *Coelaenomenodera elaeidis*, Maul.: *a*, larva; b, pupa.

Survey H.Q. Accra, 1930.



Sketch map showing the Akwapim ridge, Gold Coast, and the direction of migration of *Coelaenomenodera elaeidis*, Maul.

Survey H.Q. Accra, 1930.

The attack in July was characterised by an invasion from the N.N.E., i.e., along the contour of the Akwapim Ridge (Plate IV). This was followed by a second invasion in October from the same direction. Both these invasions reached their southernmost limits at Aburi, and the migration only occurred along the top and western slopes of the Akwapim Ridge, originating in the neighbourhood of Adakrum and Akropong, a distance of about sixteen miles.

Migration commenced at about ten in the morning on sunny days, reaching its maximum about two in the afternoon. During this time the air was thick with adults, during both migrations. Rain and cloudy weather immediately stopped flight. These migrations occurred over a period of ten consecutive days. Palms between Adakrum and Aburi were also attacked, showing that not all the beetles reached Aburi, some settling on the way. It is probable that the second invasion consisted of adults resulting from these rather than from the place of the original infestation, as palms in the latter area showed little sign of developing larvæ prior to the invasion, food material being short owing to defoliation caused by the first infestation. It has been found that a similar feature occurs with *Promecotheca opacicollis* in the New Hebrides, but on a much larger scale. Kowalski states that swarming and migration occur as soon as food material becomes short in one locality owing to previous attacks. The emerging adults then migrate a short distance and oviposit in a fresh locality; in fact, the females show an aversion to ovipositing in an already damaged tree. This is probably what occurs with *C. elaeidis*, an increase in numbers resulting in a shortage of food material and consequent migration.

The cause of the periodic increase of the beetle is unknown. Adakrum and Akropong are situated on the top of the Akwapim Ridge, and therefore exposed to storms. These storms arise from the East, to which side the ridge is most exposed. As the eggs and larvæ are heavily parasitised, it is presumed that the adult parasites, owing to their size, would be more severely affected by these storms than the host, giving the latter a chance to increase beyond its normal proportions. This theory has been put forward as the cause of the periodic increase in Fiji of *Promecotheca*.

There was no third invasion at Aburi, for natural enemies controlled the larvæ resulting from the eggs laid by those adults which did not reach Aburi during the second invasion. There were also few emergencies of adults at Aburi from the generation arising from the second invasion, parasites having overcome these. A 90% parasitisation was estimated during this generation at Aburi.

The attack mentioned as occurring in the Western Province probably originated from other causes and did not develop beyond the first generation. Here there is no high ground, and palms would not be exposed to storms to the same extent. No migration occurred in this area.

The following details of the migration of the adult beetles at Aburi are given :—

First Invasion.—July 20th, 1923 ; finished July 30th, 1923.

Oviposition commenced July 22nd ; finished approximately August 5th.

First eggs hatched August 18th ; last eggs approximately September 1st.

First larvæ pupated October 1st ; last larvæ pupated October 14th.

First adults emerged October 20th ; last adults emerged November 4th.

Second Invasion.—October 15th, 1923 ; finished October 25th, 1923.

Oviposition commenced October 18th ; finished approximately November 1st.

First eggs hatched November 14th ; last eggs approximately November 28th.

First larvæ pupated December 26th ; last larvæ pupated January 9th.

First adults emerged January 16th ; last adults emerged January 30th.

As Aburi was at the southernmost limits of the migration, it will be noticed that the next generation of adults resulting from the first invasion at Aburi did not emerge until slightly later than the commencement of the second invasion of adults, so that oviposition would naturally cover a longer period and the resulting larvæ would be in a suitable stage for parasitisation for a longer period. This was borne out by field observation of the number of larvæ parasitised and by the fact that the second invasion did not appreciably increase the number of larvæ.

Natural checks consist for the most part of Hymenopterous parasites. These are egg and larval parasites. Two egg parasites of the family Eulophidæ have been bred out. These were both new species, and have recently been described by Dr. James Waterston, of the British Museum, under the names of *Closterocerus africanus* and *Achrysocharis leptocerus* (Bull. Ent. Res., XV, pp. 392–393). The former is a minute species with dark concentric banding on the fore-wings ; it was bred out only from eggs resulting from the first invasion and was not common. The *Achrysocharis* is also a minute species with yellow legs and red eyes ; it was quite common, particularly in eggs of the second invasion.

Two larval parasites (also of the family Eulophidæ) were bred out, one attacking the young larva, the other parasitising during the latter half of larval life. Tne former, *Dimmockia aburiana*, Wtstn. (l.c. p. 385), emerges when its host is about half-grown. Not

less than three and as many as six eggs are laid in each host. The fully developed parasite larvæ emerge and pupate outside of the host, the pupæ being attached to the inside of the mine by the end of the abdomen. The pupal period is approximately eight days. The adult parasites differ very much in the sexes. The male has projecting appendages from three joints of the antennæ and has a white oval patch on the dorsal surface on the two proximal segments of the abdomen. The antennal joints of the female proximal to the elbow are white and the antennal appendages and oval patch on the abdomen are absent. The tibiæ and tarsi of both sexes are white. The female emerges slightly later than the male. This species was bred only from larvæ resulting from the first invasion. It is itself heavily parasitised by *Pleurotropis nigripes*, Wtstn. 1915 (family Eulophidæ), a small black species with white tibiæ. In the first generation under observation only 25% of the *Dimmockia* were unparasitised. Later generations appeared to be nearly totally parasitised.

The second larval parasite, *Cotterellia podagrica*, Wtstn. (l.c. p. 388) emerges from the full-grown larva and pupa. This parasite occurs singly, pupation taking place inside the host. Both sexes are bluish black, with dark wings. The proximal joints of the tarsi are white and the femora large. The antennæ of the male are hairy beyond the elbow, and the posterior borders of the abdominal segments are white. The wings are considerably darker in the female and covered with short hairs. The pupal period is from four to five weeks. The female emerges considerably later than the male, in practically all cases emerging from the pupa, whilst the male emerges from the full-grown larva, pupation taking place before pupation of the host. This species is also heavily parasitised by *Pleurotropis nigripes*.

Cotterellia podagrica was much more effective on those larvæ resulting from the second invasion, and probably it and the egg-parasites, *Closterocerus africanus* and *Achrysocharis leptocerus*, are the really effective parasites, but their action is temporarily delayed first by the effects of weather conditions and then by migration of the host. Egg-masses deposited by females of the second invasion at Aburi were parasitised up to fully 50%. *Dimmockia aburiana* is effective as a check for a short time after an increase of its host, but loses its effectiveness as its hyperparasite increases in proportion.

Other natural checks are entomogenous fungi. Owing to the high humidity these are common. A few cases of the adults of *C. elaeidis* being attacked were observed, but death probably ensues too late, oviposition having been already completed some time before. Rainfall also acts as a check; heavy rain, such as occurs during October and November, floods the larger mines, drowning the larvæ. Birds were not observed to feed on the adults, which are apparently distasteful.

Artificial controls are impossible in a country such as the Gold Coast. Shaking the leaves in the early morning or evening during

an invasion and collecting the adults at the base might be effective, but would require a large amount of labour not to be obtained on the Gold Coast. Pruning off and burning of the lower leaves at definite periods would be effective in a small way. This would destroy the more fully grown larvæ, as the larger mines would naturally be on the older leaves. A serious attack, showing no sign of abating, might warrant the breeding of parasites and transferring them to the area of infestation.

Owing to the high percentage of parasitism it is unlikely that this beetle will ever become a serious pest. Under ordinary conditions parasitism probably reaches as much as 90%, from 50% to 60% being parasitised in the egg stage. Periodic outbreaks, such as that in 1923 and previously, may occur under conditions such as are found on the Akwapim Ridge.

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PAPER No. XXXIV.

QUALITY OF PALM KERNELS EXPORTED, 1929–30.

By G. D. ROSS.

Palm kernels to-day occupy a very minor place in the export list.

The first step taken to improve this produce was the introduction, at all ports, on April 1st, 1929, of a system of inspection carried out by the Inspectorate staff of this Department. Except for the determining of defects by weight, palm kernel sampling is similar to cacao sampling. The following figures give the weighted means of analyses of 3,441 samples taken during the period April 1st to December 31st, 1929 :—

Mouldy and decomposed..	1.1%
Weevilly	0.5%
Shell and dirt	10.4%
Total defects..	12.0%

The figures give a good picture of the quality exported and indicate the defects from which the kernels suffer. The quality of this product cannot be regarded as very creditable to the producers. Certificates are issued as is done in the case of cacao.

Shell.—The manufacturers like about 2% to 3% of shell in the palm kernels, because its presence assists in keeping the rollers clean when extracting the oil. The average percentage in native trade kernels is 10.4%. This is about 7.4% more than is required, and accounts for a very great depreciation in the purchase price.

Mould.—Mould does not greatly affect the kernels, but it is a sign that there is excessive moisture, consequently a consignment would probably lose weight during shipment, and then again the moisture would show up in the oil content. The amount of moisture in well-prepared kernels is about 3%.

Insect-attacked Kernels.—Fortunately this is not a serious defect in palm kernels, but the presence of larvæ of insects indicates an inferior product. They feed on the contents of the kernels until

pupation takes place and the full-grown insects emerge from the kernels, usually leaving their pupa cases behind. The chief cause is due to the insanitary conditions of the storage accommodation. Farmers very often keep small quantities of kernels for a considerable period, i.e., until they have collected a large enough parcel to put on the market. Such conditions are a happy breeding ground for these insects and are centres for infecting fresh kernels.

Oil Content of Kernels.—Consignments of palm kernels are sold on the Liverpool markets according to their oil content. The present basis is 49% oil, with a rebate of 1½% of the quoted price for each 1% of oil less than 49%, and a premium similarly calculated for percentages higher than 49%. The other 51% is made up of moisture and feeding-cake material for cattle.

The usual analysis of palm kernels which are exported from the Gold Coast by the Palm Oil Estates Managers, Ltd., is round about 53% of oil. Sometimes a reduction is made for a slight increase in free fatty acids, which is caused during the busy season by large heaps of kernels being piled up for a comparatively long period and sweating.

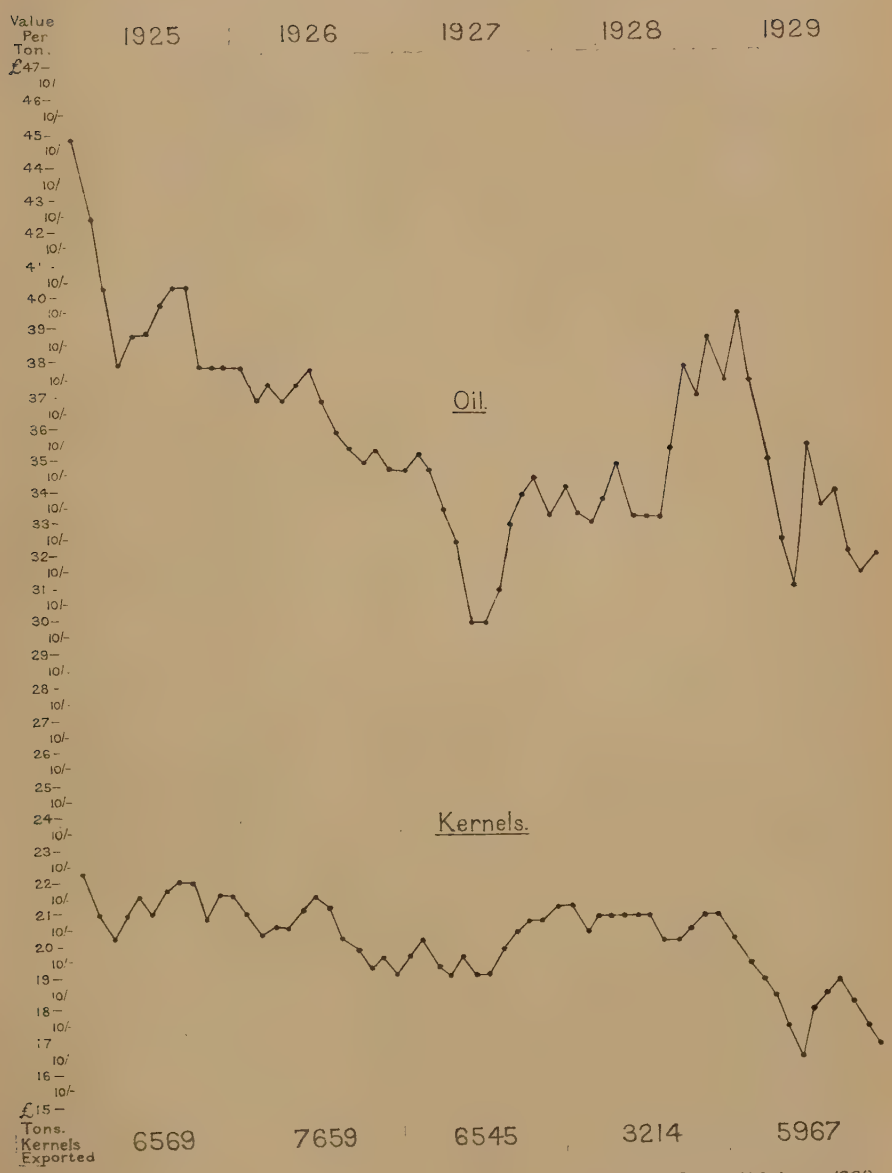
The usual analysis of native trade kernels is about 43% oil content. There is, therefore, a considerable difference between the purchase price of native trade kernels and those produced under factory conditions by the Palm Oil Estates. The cause of this difference is due to the fact that native trade kernels contain a very high percentage of defects which produce an inferior product.

Grade.—There should be eventually only one grade of palm kernels exported, i.e., containing not more than 4% by weight of shell, fibre, rotten or decayed kernel, or extraneous matter, and the kernels should be thoroughly dry and hard. If a Grade II be allowed, middlemen would flood the markets with palm kernels of a very inferior quality, and the result would be to undo any of the work done in exporting palm kernels of first quality.

The proposed scheme for financial assistance on the part of the Gold Coast Government, to approved firms or persons, for the purpose of extracting palm oil and kernels from the palm fruit purchased is a step in the right direction to help revive the declining industry and, at the same time, improve the quality of this produce. As the uses of palm kernels become more specialised and the market expands the demands are bound to increase for kernels of standard guaranteed quality. This quality can be satisfactorily accomplished if cracking machines be used and the kernels stored under suitable conditions.

The exports of palm kernels for the year 1929 (nine months) are as follows :—

PALM OIL & KERNELS
Liverpool Ex-Quay Prices.



Survey H.Q. Accra, 1930.

Accra	1,905 tons.
Winneba	444.9 ,,
Saltpond	634.0 ,,
Cape Coast	179.0 ,,
Takoradi	85.5 ,,
Total	3,248.4 tons.

The attached graph shows the relative price of palm oil and kernels for the years 1925–29, also exports of kernels for these years.

PAPER No. XXXV.

COTTON TRIALS AT TAMALE, SEASON 1928–29.

By J. E. SYMOND and T. LLOYD WILLIAMS.

During the preceding seasons 1926–27 and 1927–28 Allen cotton from Nigeria was grown on a field scale at Tamale and large quantities of seed were distributed free to farmers in the district, the produce being purchased for 2d. per lb. seed cotton. Yields during these two seasons were very low, averaging 18 and 34 lbs. per acre on Tamale Station, and even lower in the district, where it became evident that a considerable quantity of the seed issued was being wasted.*

Definite investigational work was therefore commenced in 1928 at Tamale into the causes of the very low yield of the crop, and many new varieties were tried. The district scheme was reduced to proportions which allowed close supervision and inspection, being restricted to villages within 40 miles of Tamale.

A bonus of 10s. per acre for cotton grown as a pure stand was offered to stimulate production.

This article will therefore deal with

A. Investigational work at Tamale.
B. Results in Western Dagomba District.

The writers at this stage wish to emphasise that the results discussed below are from one season's work alone, and must therefore be interpreted with caution. Especially is this so in such a district as Tamale, which is subject to a most erratic rainfall, which in the last 19 years has varied from 32 inches to 62 inches per annum, with a mean of 42 inches. The accompanying rainfall histogram (Plate I) shows the extreme monthly variation possible, which greatly complicates the problem of cotton growing. Work over a number of years will be necessary before recommendations can safely be made.

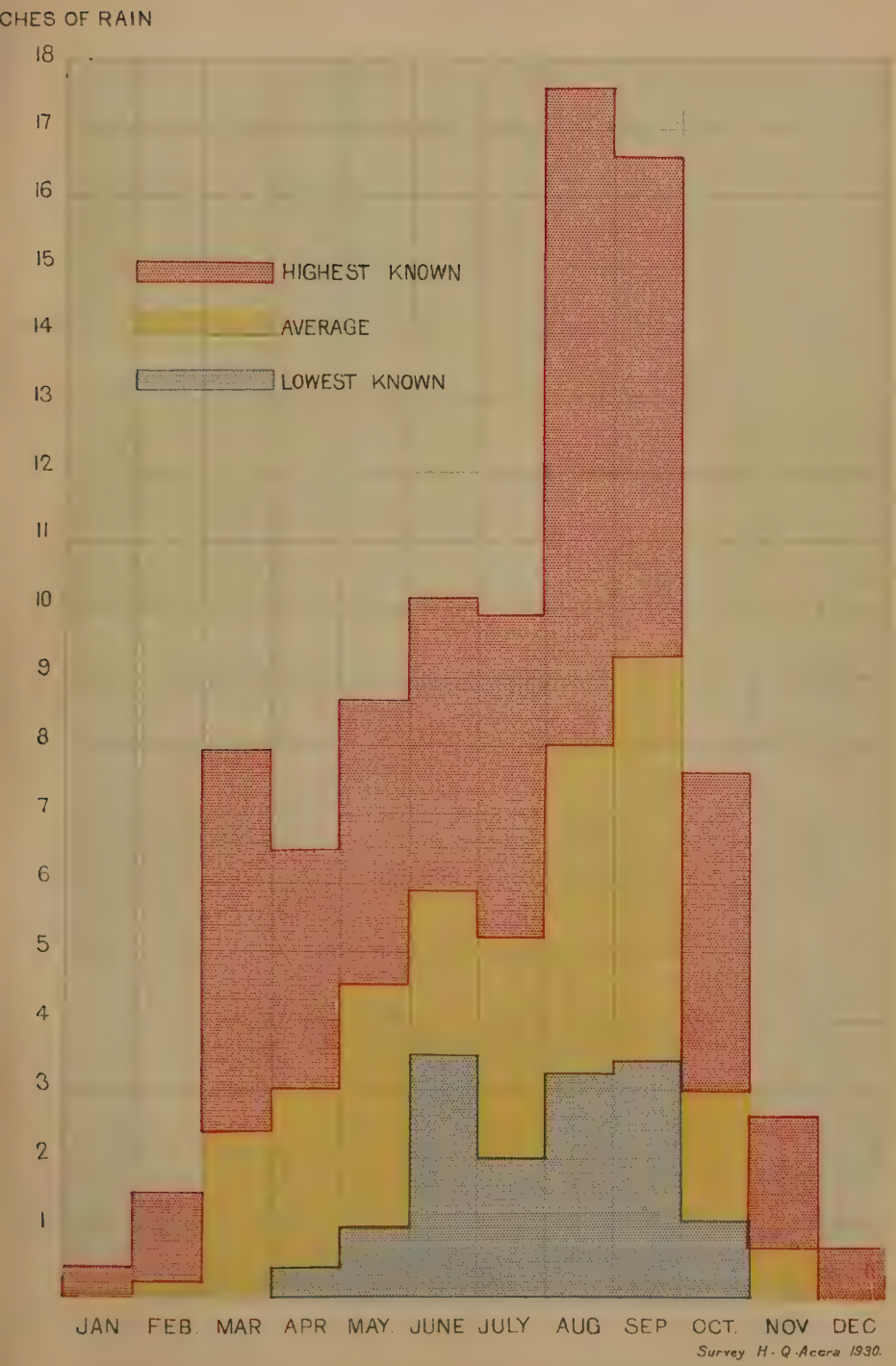
A. INVESTIGATIONAL WORK AT TAMALE.

An area of 93 acres of cotton was grown at Tamale during the season and twenty-one varieties were tested, six on a field scale. Different tillage treatments were given, including ploughing, disc

* This question has been dealt with by A. C. Miles and G. C. Coull in Paper xxxv of 1928 Year-Book.

TAMALE. VARIATION IN RAINFALL FOR ANY PARTICULAR MONTH

17 YEARS RECORDS.



harrowing, hoeing, ridging and planting on the flat. Of the varieties grown fifteen were complete failures, namely, C.O.I.A., Griffin, C.O.I., Improved Bancroft F, Sonko 22H, Improved Bancroft D, Zululand Hybrid, Uganda, 440 var, Improved Barberton, Allen strains 23.14, 23.3., 25.1, and Ishan strains A28 and B28. The yields from the remaining varieties and their respective treatment are given in the following table. The names " Ashanti Rough and Smooth " and " Allen Smooth " have been given merely for the sake of convenience to smooth and fuzzy seeded cottons extracted from mixed consignments of seed received.

Variety.	Acreage.	Treatment.	Mean Yield lbs. per acre.
Allen	14	Hoed. Planted on flat	25
Allen	26	Hoed. Ridged	38
Allen	5	Ploughed and planted on flat ..	44
Allen smooth ..	5	Ploughed and planted on flat ..	21
Ishan	15	Ploughed and harrowed on flat ..	63
Ishan	11	Hoed and ridged	43
Ashanti smooth	2.13	Hoed. Planted on flat	43
Ashanti rough ..	5	Ploughed and harrowed on flat ..	19
Hartsville ..	⅛	Hoed and planted on flat ..	33½

In addition, optimum planting time trials and spacing trials were carried out, the former at five-weekly intervals.

The highest yield on the station plots was 98 lbs. per acre from a 5-acre block of Ishan, and the lowest 14 lbs. per acre from a 5-acre block of Allen. The mean yield over the whole station area was 40 lbs. per acre. Ishan, a late maturing variety, appeared the most promising, and a field scale trial with earlier planting was laid down in 1929.

Results of tillage trials are inconclusive at present and must be continued over a series of years. The work now divides itself into two main sections :—

I. Physiology and Disease.
II. Breeding and Selection.

SECTION I. PHYSIOLOGY AND DISEASE.

It was desired to investigate the following characteristics of the main varieties of cotton grown.

(*a*) Types of flowering, shedding and harvesting curves.
(*b*) Incidence of the various pests and diseases mainly responsible for shedding.
(*c*) Damage in harvested bolls, especially in connection with bollworm attack.
(*d*) Period from flowering to maturity.
(*e*) Stainer (*Dysdercus* spp.) index.

Methods.—The above characteristics were studied by means of sample plots of one-eighth of an acre. Each plot was divided, one-half being used for the stainer index.

On each plot all the flowers were counted daily and the shed buds and bolls collected and classified according to cause, i.e., boll-worm, stainer, physiological and other injuries—in this case mainly fungus disease. When harvesting was started the ripe bolls were picked once a week from each plot and classified according to the damage. Observations were carried out on twenty-four one-eighth of an acre plots in all.

(a) Types of Flowering, Shedding and Harvesting Curves.

The flowering, boll shedding and harvested boll figures of the main areas of Allen and Ishan are given in the form of a graph in Plate II. The plots from which the Allen figures were taken gave remarkably uniform results.

It will be observed that, in spite of a common planting date, the Ishan variety is no less than five weeks later in flowering than the Allen. The latter shows three well-developed flowering peaks, the first two of which are rapidly overtaken by the shedding curve, whilst it is from the third flowering peak alone that any appreciable harvest is obtained. Ishan can be said to have only one main flowering peak, corresponding with the third Allen peak, and it is again from this that the bulk of the harvest is obtained.

This would lead one to believe that the bolls produced by the plant in the early and rainy part of the season cannot be held on account of excess moisture in the soil, and that it is not until the advent of drier conditions that they can be retained by the plant until they mature.

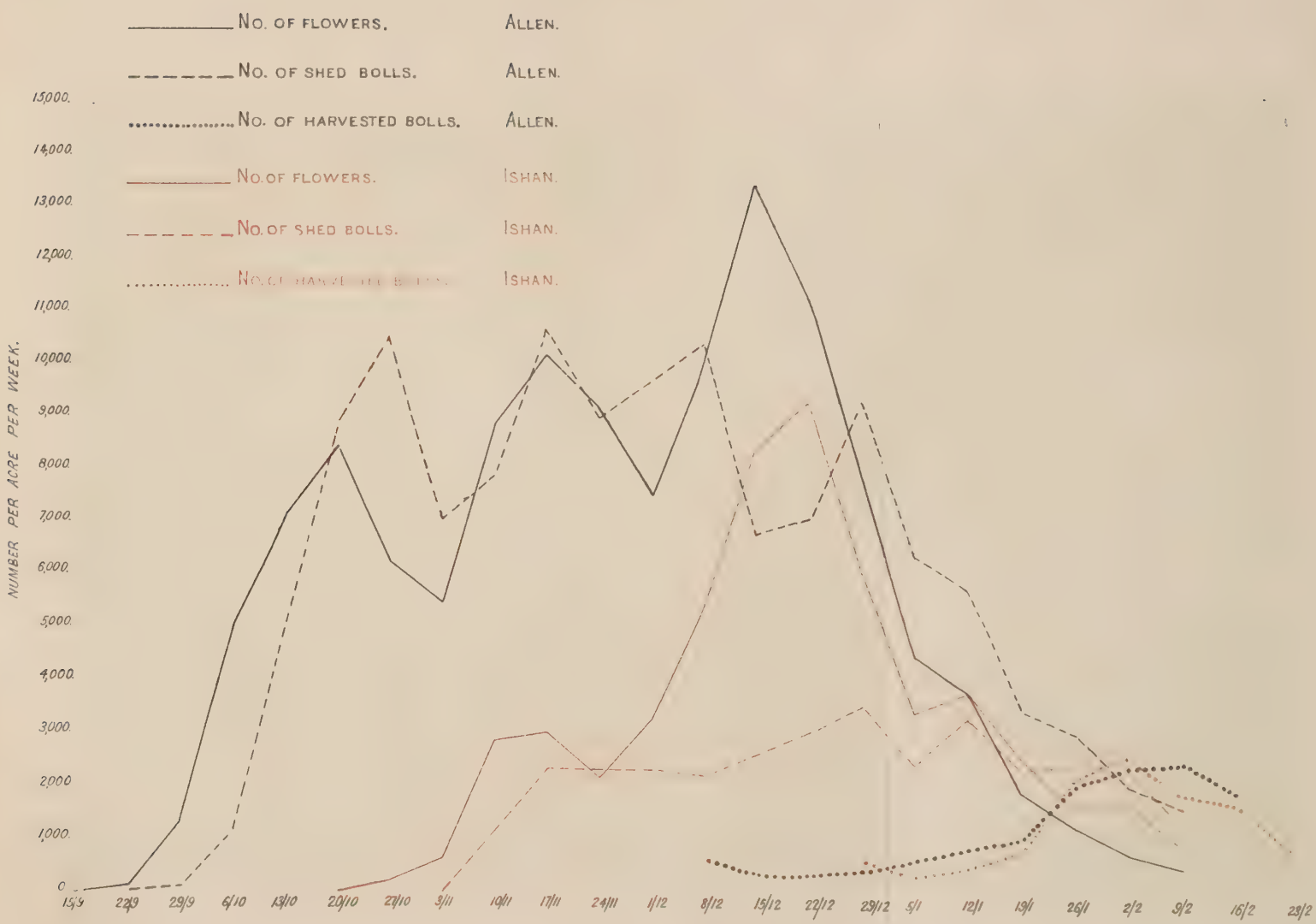
On the "optimum planting time plots" the flowering and shedding curves differed greatly, showing that planting date has a big influence on the development of the crop. For this season the earliest and latest plantings were most successful, but it is considered that no useful purpose would be served by publishing the figures of one season's work when the great seasonal variability is taken into account. The range of planting time is being considerably extended in 1929.

A feature of all the curves taken was the high shedding percentage, rising to 90.3% in the main Allen crop. A fairly high percentage of shedding is, of course, normal in cotton, 60% to 65% for Allen being regarded as normal in Nigeria over a series of years (Reference 6th Annual Bulletin, Nigerian Agric. Dept., p. 34).

The cause of the excessive shedding in Tamale is not yet determined. It is very probable, however, that two of the main factors are poverty of the soil and waterlogging. The soil of the district in general is of a very light sandy nature, with a hard pan of semi-

TAMALE INVESTIGATIONAL STATION

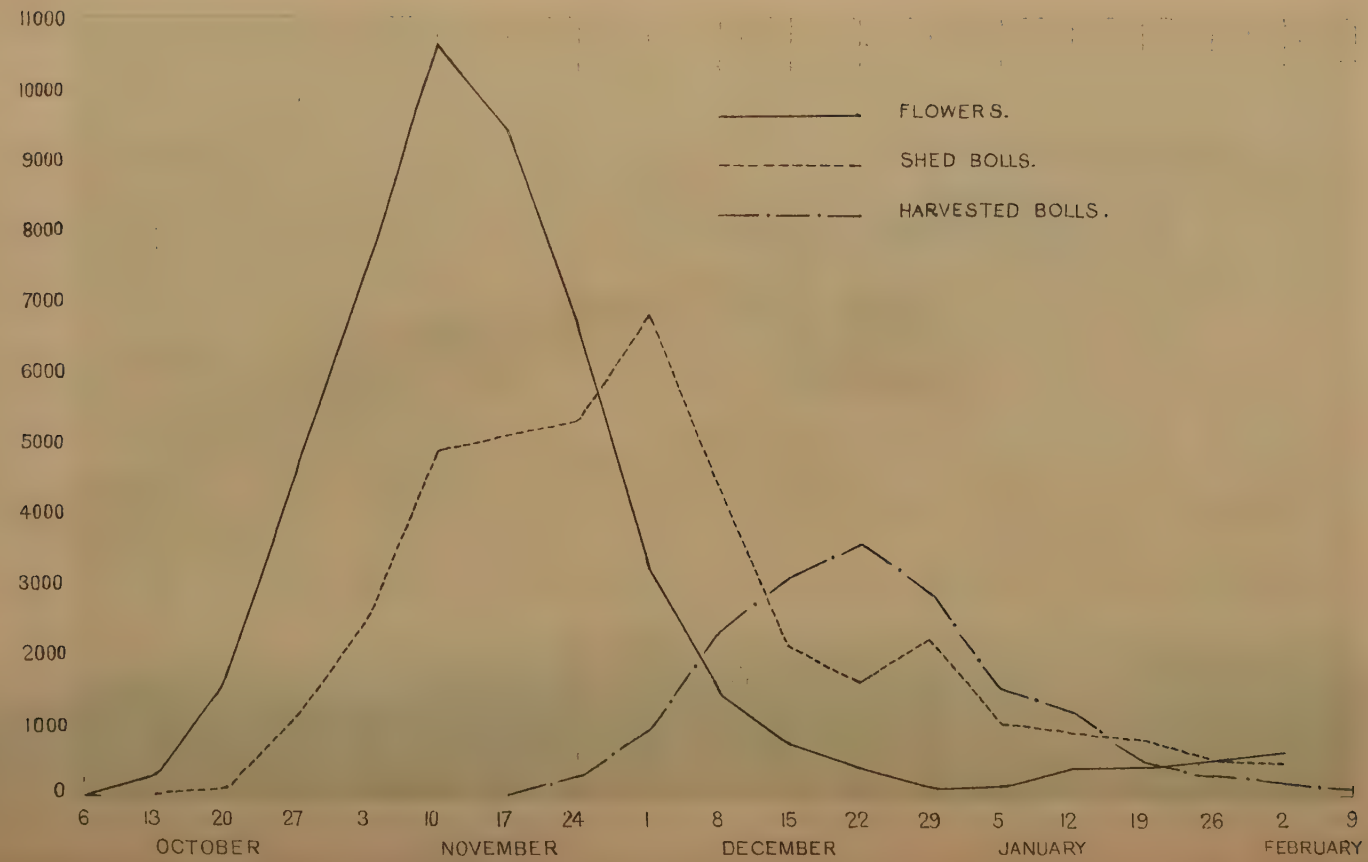
COTTON TRIALS, SEASON:- 1928-1929.



Survey H.Q. Accra, 193

I ACRE ALLEN PLOT.

NO. OF FLOWERS, SHED BOLLS, AND HARVESTED BOLLS PER ACRE PER WEEK



permeable laterite (Pisolite cement) close below the surface. Below this again in parts is impermeable shale, and in the height of the rainy season seepage water runs so close to the surface that serious waterlogging may occur. At several points on the Tamale Station at this time water breaks out of the ground in the form of surface springs.

This theory is supported by Plate III, which gives the curves from a 1-acre plot of Allen cotton planted on a better soil and with better natural drainage. Here it will be seen that a far more normal curve is obtained, i.e., a single peak in each curve, the peak of the flowering curve occurring approximately at the same time as the middle peak in Plate II. The shedding here drops to 71.8%, though the total flower production is very much less.

(b) Disease and Shedding.

The shed bolls were collected and classified as far as possible according to the cause of shedding, as follows :—

(i.) *Stainer Injury.*—This figure is only approximately correct as it is sometimes impossible to separate this from fungus and bacterial injuries classified under " Other Injuries."

(ii.) *Bollworm.*

(iii.) *Physiological.*—Those bolls which show no sign of any pest or disease attack and are the excess bolls which the plant ripens.

(iv.) *Mummied Bolls.*—Those attacked by such disease as internal boll rot and anthracnose, which, instead of shedding, shrivel up and remain on the plant in a mummified condition.

(v.) *Other Injuries.*

The following table gives the percentages of disease for Allen and Ishan :—

TABLE A.

ALLEN.

Date.	Stainer.	Bollworm.	Physio-logical.	Other injuries.	Mummied bolls.
October	22%	22%	21%	35%	1%
November ..	21%	22%	22%	35%	1%
December ..	22%	22%	23%	33%	0.4%
January	12%	20%	25%	43%	2%
February ..	13%	19%	36%	32%	0.9%
Total crop ..	19%	22%	23%	36%	1%

TABLE B.

ISHAN.

Date.	Stainer.	Bollworm.	Physio-logical.	Other injuries.	Mummied bolls.
October	—	—	—	—	—
November ..	9%	22%	30%	39%	—
December ..	12%	22%	29%	37%	—
January	13%	19%	27%	41%	—
February ..	10%	14%	31%	45%	—
Total crop ..	11%	20%	30%	39%	—

Thus the most serious diseases are those bacterial and fungus diseases placed under the heading of "Other Injuries." Undoubtedly a considerable number of these must be due to internal boll disease from stainer attack. It will be seen that the percentage damage due to bollworm remains remarkably constant for Allen throughout the greater part of the season, whilst decreasing more rapidly for Ishan.

Physiological shedding increases in February, by which time the ground is very dry and the plant cannot hold its bolls.

(c) Damage in Harvested Bolls.

The bolls from the sample plots were harvested and classified once a week. The following table gives the percentages for Allen and Ishan :—

TABLE C.

MAIN ALLEN CROP (FIGURES PER ACRE).

	Mummied Bolls.		Open Bolls.				
Date.	Total No. of mummied bolls.	% with bollworm injury.	Total No. of harvested bolls.	Useless bolls.	Bolls with two or less locks good.	Bolls clean or slightly stained.	Bolls with bollworm injury.
December	1,420	80%	2,052	31%	39%	30%	61%
January	2,176	67%	8,444	16%	30%	54%	34%
February	1,380	66%	8,800	28%	23%	49%	33%
Total and Mean %	4,976	70%	19,296	23%	28%	49%	36%

TABLE D.

ISHAN.

December	196	81%	644	17%	32%	51%	42%
January	852	60%	4,568	16%	32%	52%	39%
February	1,216	56%	5,932	23%	23%	54%	31%
Total and Mean %	2,264	59%	11,144	20%	27%	53%	35%

The amount of damage is very high, as only 49% Allen and 53% Ishan of the open bolls harvested are undamaged. The two main causes of damage are bollworm (36% and 35% of the bolls showing damage from this) and internal boll disease, due mainly to stainer attack. A point of importance is that in both varieties, and both for mummied and open bolls, the percentages of bollworm damage decrease from December to February.

(d) The Period from Flowering to Maturity.

Between October 5th and November 9th approximately 300 flowers on Allen plants and fifty on Ishan were marked with small dated tin labels. The date of ripening of each boll was recorded. For Allen the following results were obtained :—

No. of days ..	41,	42,	43,	44,	45,	46,	47,	50
No. of bolls ..	1,	2,	2,	2,	8,	5,	2,	1

This gives a mean of 44.9 + 0.377 days.

The figure thus obtained corresponds with the interval found between the flowering and harvested boll curves.

Owing to the excessive shedding of the marked bolls no figures could be obtained for Ishan.

(e) Stainer Index.

A stainer index was taken at the request of the Entomological Division, and is shown for Allen cotton in the following table. The figures are expressed in terms of one-eighth of an acre plot :—

Week Ending.	*D. Superstitiosus.*			*D. melanoderes.*
	Spotted.	Banded.	Nymphs.	
6/10/28 ..	8.4	—	—	—
13/10/28 ..	109.6	—	—	—
20/10/28 ..	171.3	1.3	—	—
27/10/28 ..	83.2	1.2	—	—
3/11/28 ..	63.6	2.8	—	—
10/11/28 ..	25.6	88.0	70.8	—
17/11/28 ..	18.4	0.8	174.0	—
24/11/28 ..	10.8	4.8	244.8	—
1/12/28 ..	8.8	13.6	142.8	—
8/12/28 ..	28.0	24.4	86.0	—
15/12/28 ..	42.4	6.4	10.0	—
22/12/28 ..	10.8	2.4	3.6	2
29/12/28 ..	8.0	1.0	—	1
5/ 1/29 ..	23.0	3.0	—	1
12/ 1/29 ..	23.2	2.8	1.2	1
19/ 1/29 ..	49.0	20.0	—	—

SECTION II. BREEDING AND SELECTION

This section may be divided into four parts: (*a*) that dealing with the further selection and purification of selections made during the 1927–28 season; (*b*) that dealing with the field selections made in the 1928–29 season; (*c*) hybridisation; (*d*) new types to be grown.

(a) Reselection of 1927–28 Selections.

Seven plants of Allen type and one of a native type (Gumanli) were selected last season and planted out on the plant-to-row method this season.

The plants were all numbered and the flowers selfed daily, a record being kept of the number of flowers produced on each plant daily.

When the bolls ripened they were harvested separately, and the number of locks per boll and the number of bolls per plant, as well as the date, were recorded.

As was expected, a great amount of variability in all characters was present. The obviously useless plants were "rogued" during the growing season and one of the parent lines was completely discarded. Finally, fourteen of the more promising plants were harvested from the remaining seven lines and examined as to yield and lint characters. On this preliminary selection six plants were discarded. The remaining eight were examined in detail, particular regard being paid in selection to yield, lint length, lint strength and ginning percentage. Four were chosen to be grown next season.

Their most important characters are :—

	D28	F44	D32	E7
Yield (gms.)	99.7	69.6	47.5	56.5
Lint length ( ) ..	17.41	16.42	18.08	17.34
Ginning %	30.0	29.31	32.25	31.1
No. of locks per boll ..	4.0	4.35	4.0	4.12
Boll shedding % ..	83.1	56.6	74.2	76.3

(b) Field Selections, 1928–29.

All the fields of cotton were examined and seventy-eight plants chosen for preliminary examination.

All the flowers on these plants were selfed in order to keep the lines pure

At harvesting, fifty-five were rejected, and, finally, sixteen American, five Ishan and two Hartsville plants were examined in

detail and treated as the selections in (*a*) above. The following are some of the more important characters of the plants finally selected :—

I. AMERICAN.

	T66 Ashanti smooth.	T68 Allen.	T67 Ashanti rough.	T57 Allen smooth.	T75 Allen new.	Hart 1 Harts-ville.	Hart 14 Harts-ville.
Yield (gms.). ..	243.7	127.7	153.6	98.0	66.2	50.6	40.1
Lint length ($\frac{1}{16}''$)	17.31	18.18	16.76	18.45	18.78	17.47	18.2
Ginning % ..	28.24	27.35	35.5	33.2	32.4	33.9	35.5
No. of locks per boll	4.02	3.87	4.77	3.86	4.0	4.0	4.0
Weight of cotton per boll ..	2.67	3.87	2.7	3.77	4.74	4.05	3.71

II. ISHAN.

	T106	T109
Yield	72.8	116.5
Lint length ($\frac{1}{16}''$)	17.87	18.61
Ginning %	33.9	32.7
No. of locks per boll ..	3.0	3.0

It will be noted that several of these plants gave a very good yield, combined with a good lint length, i.e., $1\frac{1}{8}$ inches or over. It may be mentioned that none of these plants appeared to be unduly favoured by its environment.

They will all be grown on the plant-to-row method and treated as in (*a*) above.

(c) Hybridization.

A number of selected Allen plants were crossed with pollen from two particularly vigorous native plants (Gumanli), as it may be possible to combine the vigour of the native cotton with the lint characters of Allen.

Owing to excessive shedding only four bolls ripened. These, however, are being tested in 1929.

(d) New Types.

The following new types of cotton will be tried next season :—

(i.) A promising native type named Ganvelga from the village where it was found.

(ii.) A sample of Asiatic cotton received from the Plant Breeding Station in Turkestan.

(iii.) Various South African and Nyasaland types.

B. RESULTS IN WESTERN DAGOMBA DISTRICT.

During the season distribution of seed was confined to villages within a radius of, roughly, 30 miles from Tamale.

Allen seed alone was used for this work. Growers were promised a bonus of 10s. per acre for cotton grown as a pure stand, and, except in cases of exceptionally well-cultivated farms, no bonus was given for less than 1 acre. All seed cotton was to be purchased at 2d. per lb. The greater part of the seed distribution was completed in June, and the whole by the first week in August, delay in the delivery of imported seed being the cause of a few districts receiving cotton later than June. As the rains were late, all seed was out in good time for planting.

At the time of distribution representatives from every village were collected at various centres and given as much seed as they required, while, at the same time, the bonus scheme was carefully explained to them. No attempt was made to urge the people to grow more than they themselves wished to do. A total amount of 5,578 lbs. of seed was thus distributed among 348 villages.

During the growing season the district was very thoroughly toured, every village being visited and each farm measured.

A total of 351.7 acres was grown by the 348 villages, though of the native variety of cotton interplanted among foodcrops (the extent of which cannot accurately be measured) there was at least an equal area.

The response to the bonus scheme was very fair, 227 acres of the 351, or 64%, receiving a bonus.

The largest farm was, as in the previous year, that of the Chief of Iungbungu, a keen and thorough farmer, who put in 15 acres. As the farms were inspected and measured, a ticket was issued to the farmers recording the acreage grown and the amount of bonus payable, and they were instructed that this must be brought in with the produce from their own farms alone. This method has been very useful in stopping the system whereby the chiefs collected the cotton from a district and received the total payment for the produce, and has enabled a large range of yield figures to be amassed. A total of 10,401 lbs. seed cotton was finally brought in from the district. This was a great advance on the previous season, as may be seen from the following table :—

	Seed Distributed.	Seed Cotton brought in.
1927–28	11,786 lbs.	4,725 lbs.
1928–29	5,578 lbs.	10,401 lbs.

Yields varied from 116 lbs. to 8 lbs. per acre. The best large farm, that referred to above, produced 1,268 lbs. from 15 acres, or 85 lbs. per acre. With the bonus added to the purchase-price of the cotton, this farmer realised £17 for his crop, equivalent to 3¼d. per lb. seed cotton.

Assuming a ginning percentage of 30%, this is equivalent to nearly 11d. per lb. for cotton lint delivered in Tamale, without the cost of ginning being taken into account.

This, however, is an exceptionally good farm, and the average yield from the whole district did not exceed 30 lbs. per acre. With bonus this is equivalent to 6d. per lb. for seed cotton, or over 1s. 6d. per lb. for lint. The cost of actual ginning is low, being approximately .02d. per lb. lint, though this figure does not include supervision or depreciation and capital redemption charges on the ginnery.

Transport to Kumasi is 1d. per lb. lint, and from there to its final market probably less than a further 1d. per lb. The price realised for this cotton last year in England was 11d. per lb.

SUMMARY.

1. The results of the past season's work have now placed us in a position to say what is the cause of the continued low yield of cotton in the Northern Territories. It is undoubtedly due to excessive boll shedding coupled with a high percentage of insect damage. The next step will now be to investigate why the boll shedding is excessive. The theory is tentatively advanced that it is due to soil poverty, especially in humus, and excessive waterlogging. Investigations to this end are in the programme for the coming season.
2. It was previously supposed that damage due to insect pests was not serious, but the results of one year's work have shown that this may become a limiting factor in high yield production.
3. The smaller percentage of the Ishan variety in boll shedding is noteworthy. This variety has a good lint length and fair ginning percentage (27.5%).
4. The district scheme has shown that the average yield is still far below the economic lint. With the present bonus the cost of lint delivered in Tamale varies from 11d. per lb. from the best farm to 1s. 6d. per lb. from the estimated average. As the price received in England after ginning and transport is only 11d. per lb., the subsidy in which Government is involved by the bonus scheme and purchase is too great when there is no prospect of improvement or expansion. Assuming that investigational work is suc-

cessful in producing a high yielding strain, it must be at least five years before sufficient pure seed is available for large-scale distribution. In that event it would also be vitally necessary either to have an Ordinance prohibiting the growth of the low-yielding native and introduced varieties or the establishment of a rigidly-controlled large scale pure seed farm.

It has therefore been decided that the promotion by Government of cotton growing be for the present confined to the production, if possible, of a high yielding strain, which must be thoroughly tested on a large scale before extension work is undertaken.

5. No great difficulty need be anticipated in restarting this crop if it can definitely be proved worth while for the farmer. Seed was issued during 1929 on request to any district, but the purchase and bonus scheme is being held in abeyance indefinitely.

PAPER No. XXXVI.

COTTON DEVELOPMENT, NORTHERN TERRITORIES, 1929–30.

By J. E. SYMOND and T. LLOYD WILLIAMS

During the previous season, with a carefully organised scheme of seed distribution, bonus and purchase of seed cotton at 2d. per lb., it was found that yields were too low for the crop to be grown economically. Government was obviously involved in too great a subsidy by giving bonus on an acreage system, and it was decided to leave the district scheme in abeyance until such time as a comparatively high-yielding strain could be evolved.

The same low yields were obtained in field scale trials at Tamale Investigational Station. Experiments during that season tended to show that cotton suffered definitely during the height of the rainy season from excess moisture, and from observation it was thought that soil poverty, especially in humus, was a limiting factor in high yield.

Work during 1929–30, the season at present under review, was therefore practically confined to Tamale Station, and for this report may be divided into the following parts :—

I. Improvement of strains by selection and breeding.

II. Continued study of physiology and disease on :

(*a*) Optimum time planting.
(*b*) Manurial experiments.
(*c*) Further field scale trials with Ishan variety.

III. (*a*) Cotton as part of rotation farming.
(*b*) Small observation plots of Ishan variety at out-stations.

These sections will now be discussed in detail. It is only possible in this paper, to illustrate certain points in the discussion, to give a selection of the very large number of the graphs made.

PART I.—SELECTION AND BREEDING WORK.

This part will be divided into six sections :—

(*a*) General method of work.
(*b*) Further selection and purification of selections made during the 1927–28 season.

(*c*) Further selection and purification of selections made during the 1928–29 season.

(*d*) Field selections made in 1929–30 season.

(*e*) New varieties tested during 1929–30.

(*f*) New types to be grown.

(a) General Method of Work.

All the selections and new varieties to be tested were sown on Station Block 21. This block was under Allen cotton during 1928–29, giving a yield of only 29 lbs. seed cotton per acre. Methods of examination in the laboratory were as follows :—

Lint Length.—The paraffin slide method was used for ginned cottons. A careful sample is taken and 100 individual hairs measured on a glass slide, graduated in sixteenths of an inch and moistened with paraffin. The mean gives a length approximating to the commercial lint length. The combing method, which is much quicker, was used for the bulk of the samples. Here the lint on the seed is combed out, measured in three positions, and the mean taken. The number of seeds measured depended on the size of the sample, and varied from ten to twenty. If 2.5 to 3.5 sixteenths of an inch are added to these results, a lint length comparable to that derived from the paraffin slide method is obtained. Unless otherwise indicated all the lint lengths in the following tables were obtained by combing.

Ginning Percentage.—All cottons were ginned on a hand-roller gin. Higher values are obtained than on a commercial scale.

Strength.—This is judged arbitrarily on a basis of points, ten being very strong and five medium.

Texture.—This is also judged arbitrarily and placed in one of the following classes : silky, medium silky, medium, medium harsh and harsh.

Baer Diagrams.—The Baer sorter is an apparatus in which, by means of combs, the constitution of any cotton can be determined and the fibres arranged according to length. Photographs of several strains of cottons are given in this report.

(b) 1927–28 Selections.

Three of these, F44, D28 and D32, were planted, each in a one-thirty-sixth of an acre plot, at a spacing of $1\frac{1}{2}$ by 4 feet, giving a maximum of 200 plants per selection. All obviously bad and unhealthy plants were rogued, promising plants were individually harvested, and the remaining plants harvested in bulk. Table I gives particulars of these three strains :—

PLATE I.

BAER DIAGRAMS.

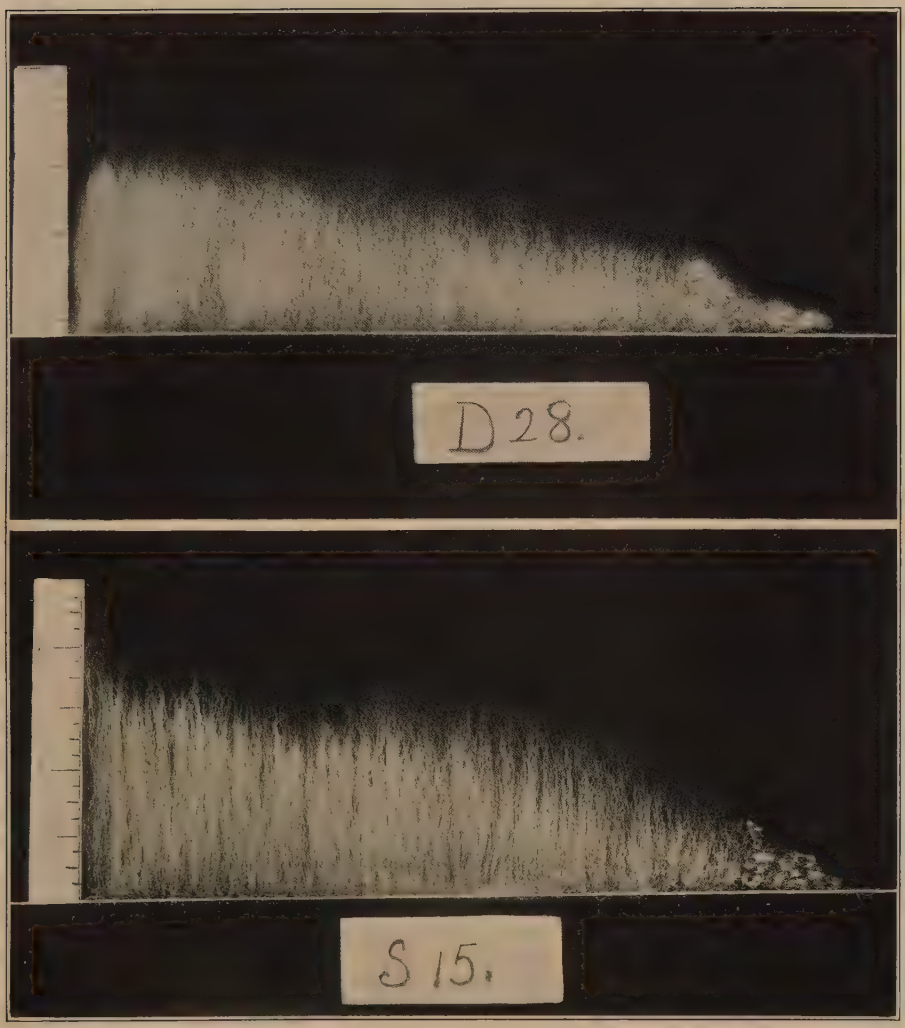


Fig. 1. Bulk Cotton of Strain D 28

Fig. 2. S 15. A Field Selection

1929-30 Season.

(Note the high percentage of very long lint).

PLATE II.

BAER DIAGRAMS.

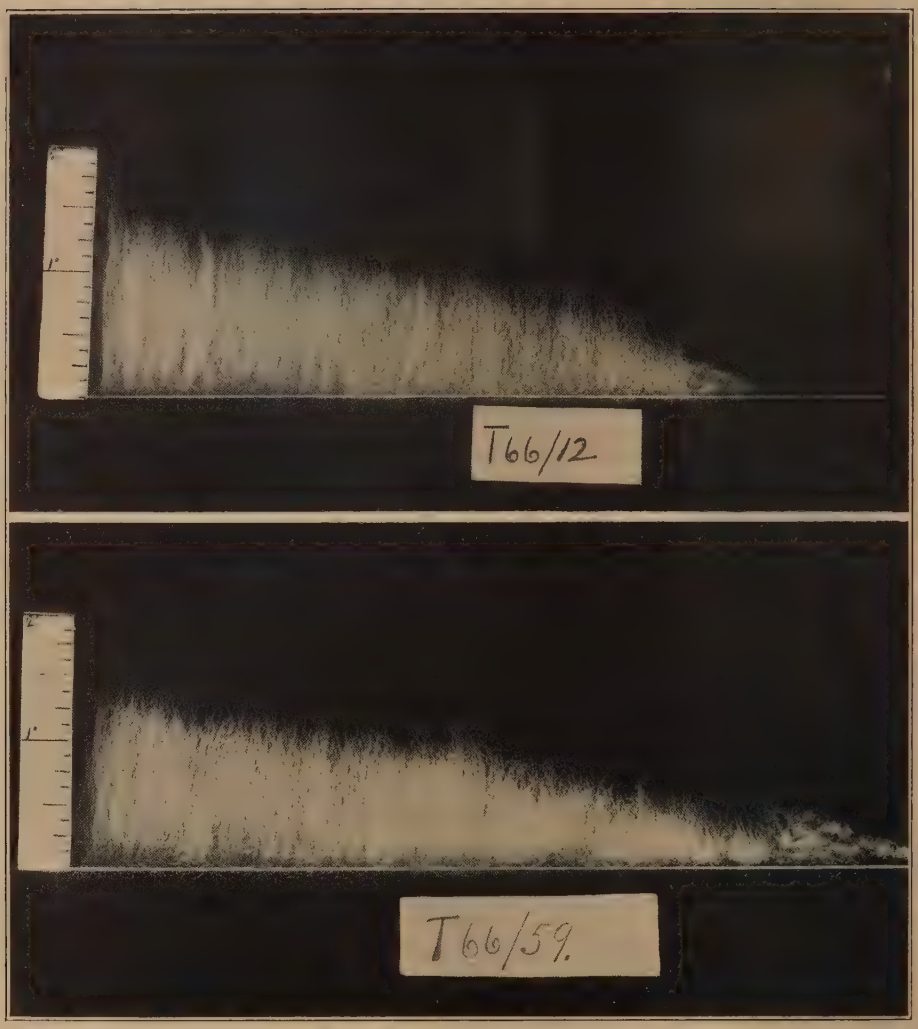


Fig. 1. Individual Plant of Strain T.66 with uniform Lint.

Fig. 2. Individual Plant of Strain T.66 with the Highest Yield.

TABLE I.

YIELDS PER ACRE, ETC., OF 1927–28 SELECTIONS.

No. of Strain.	Variety.	Seed.	Yield per Acre. lbs.	No. of Individual Plants selected.	Bulk only.	
					Ginning %	Lint Length.
D28	Allen	Fuzzy	100.7	12	32.2	17.66*
D32	Allen	Mixed	25.7	1	33.4	—
F44	Allen	Mixed	25.4	—	34.6	—

* Paraffin slide method.

D32 and F44 have been completely discarded. The individual plants in D28 have been examined and five of them will be sown next season on the plant-to-row method in order further to purify them. The characteristics of these five plants and of the parent plant are shown in Tables II and IX (*see* end of section). The remaining seven of the individually harvested plants were added to the bulk harvested and will be sown in a small multiplication plot. A Baer diagram of the bulk cotton of D28 will be seen in Plate I.

(c) 1928–29 Selections.

Eleven of these were planted in the 1929–30 season. Each selection was planted at 4 by 1½ feet in two widely separated rows, giving 200 plants per selection. Two of the strains were outstanding, viz., T57 and T66. Both were very uniform and followed their parents' characteristics closely. In both cases all the weak and unhealthy plants were rogued early, the remainder all selfed and individually harvested, further undesirable plants being eliminated as they were observed. Table III gives the data up to the time of harvesting.

TABLE III.

	*T*57.	*T*66.
Maximum number of plants	200	200
No. of plants when selfing started ..	159	165
No. of plants harvested	93	120

Tables IV, V and VI below give harvesting data and frequency tables of number of locules per boll and weight of seed cotton per boll.

TABLE IV.

Harvesting Data.

	*T*57.	*T*66.
Total plants harvested	93	120
Total bolls harvested	696	1,242
Average number of bolls per plant ..	7.5	10.4
,, weight seed cotton per boll ..	2.9 gms.	2.7 gms.
,, ,, ,, ,, plant	21.9 gms.	27.8 gms.
Yield per acre in lbs.	166.9	273.2
,, ,, ,, on a basis of number of plants harvested ..	358.9	455.3

TABLE V.

Frequency of Number of Locules per Boll per Plant.

	*T*57.	*T*66.
3.0	5	2
3.1	—	—
3.2	2	1
3.3	6	2
3.4	4	—
3.5	4	1
3.6	8	4
3.7	16	9
3.8	15	16
3.9	6	18
4.0	24	52
4.1	2	9
4.2	1	3
4.3	—	2
4.4	—	—
4.5	—	1
Total plants ..	93	120
Mean ,, ...	3.46	3.90 locks per boll.

TABLE VI.

Frequency Table of Weight per Boll in gms.

(*Allowing for Destroyed Locules.*)

Class Interval. Wt. in gms.	*T*57.	*T*66.
1.5 (1.4–1.59)	1	1
1.7	2	2
1.9	1	3
2.1	2	4
2.3	4	7
2.5	3	5

For Continuation of Table see next page.

TABLE VI—*continued.*

Class Interval. Wt. in gms.	*T*57.	*T*66.
2.7	7	16
2.9	8	12
3.1	10	8
3.3	9	18
3.5	7	16
3.7	11	7
3.9	6	8
4.1	9	6
4.3	6	3
4.5	2	1
4.7	1	—
4.9	2	—
5.1	—	—
5.3	1	2
5.5	—	—
5.7	1	—
5.9	—	—
6.1	—	—
6.3	—	1
Total number of plants	93	120
Means in gms. per boll	3.40	3.18

Both these strains arose from naked seeded parents, and the inheritance of naked and fuzzy seeds is of interest. Three types are found, naked seeds with a tuft of fuzz at the tip ; semi-fuzzy seeds which are covered with scattered short hairs and which cannot be called fuzzy ; and seeds with a definite thick fuzz which varies from white to a definite green. The ratios are as follows :—

	Smooth Tufted.	Semi-fuzzy.	Fuzzy.
*For T*57.	55	17	21
	72		21
	Expectation on a simple Mendelian Ratio.		
	69.75		23.25
*For T*66.	Smooth Tufted.	Semi-fuzzy.	Fuzzy.
	61	23	36
	84		36
	Expectation as above.		
	90		30

It will be noted that in both strains there is a significant 3 : 1 ratio between non-fuzzy and fuzzy. Hence it is considered highly probable that the recessive fuzzy seeded plants will breed true to

character next season, whilst it should be possible to isolate a strain breeding true to naked seed without undue difficulty, *i.e.*, a strain homozygous for naked seed. As yield is one of the most important characters, the plants from these two strains T57 and T66 were divided into four classes :—

(1) Plants giving over 50 gms. of seed cotton.
(2) ,, ,, ,, 25–50 ,, ,, ,,
(3) ,, ,, ,, 10–25 ,, ,, ,,
(4) ,, ,, under 10 ,, ,, ,,

The distribution of plants in these classes is of interest and is shown in Table VII below :—

TABLE VII.

	No. of Plants.	% of Total Plants.	% Total Yield.
Strain T57			
Under 10 gms.	29	31.2	5.1
10–25 ,, ...	29	31.2	24.3
25–50 ,, ...	30	32.3	53.4
Over 50 ,, ...	5	5.3	17.2
Strain T66			
Under 10 gms.	29	24.2	4.9
10–25 ,, ...	37	31.0	19.2
25–50 ,, ...	34	28.3	33.6
Over 50 ,, ...	20	16.5	42.3

All cotton was examined for lint length, ginning percentage, texture and strength. To purify the strains further, nine of the best plants of T57 and ten of T66 were chosen, in each case from the two higher classes in Table VII above, to be grown on the plant-to-row method. Full particulars of these plants and the corresponding data for their parent strains will be found in Tables VIII and IX at the end of this section.

The remaining plants of T57 and T66, together with any surplus over 300 seeds each of the nineteen special ones, will be grown in small multiplication plots for the purpose of increasing the strains rapidly. Smooth and fuzzy seeded types were separated. The limiting characteristics below which any plant was altogether discarded were as under :—

Lint length	$\frac{14}{16}$th inch (approx. $1\frac{1}{16}$th inch commercially).
Ginning percentage ..	27.
Texture	Below medium.
Strength	Below 4 points (5 = medium).
Vegetative	Any poor or diseased plant.
Yield	Depending on above points.

In T57 thirty-four plants were finally chosen for multiplication (non-fuzzy twenty-seven and fuzzy seven) and forty-eight from T66 (thirty-one and seventeen). Apart from these two strains T57 and T66, the nine remaining 1928–29 selections were completely discarded except three from a strain T68 and three from T75, which will be grown on plant-to-row method. The characteristics of these plants are given in Table X (*see* end of section).

(d) Field Selections, 1929–30.

The general seed supply was very mixed, and many hybrids between Allen and Ishan were noticed. The F1 hybrid in general is a fine vigorous plant, with good cotton and a high yield. These plants are characterised by a pink petal spot. They will, however, split up next season. A certain number have been selected and will be put in the plant-to-row lines, as it may be possible to isolate some of the highly desirable characters. All the cotton fields were examined and fifty plants selected. Of these eight were discarded in the field, and after harvesting fifteen finally selected for planting. Their characteristics are given in Table XI. S15 is particularly noteworthy, as it has a lint length of over 1¼ inches, is of silky texture and very uniform. A Baer diagram is given in Plate I (fig. 2).

S31 is also of interest, as it suggests a cross between a native type and an American. The plant is profusely branched from the base, and has very small bolls, some arising from extra axillary buds. The leaves, especially the younger ones, have a peculiar greyish tint, due mainly to extreme hairiness. The young branches are extremely hairy. The lint is short, but as the plant was highly resistant to disease it will be grown on.

(e) New Varieties Tested, 1929–30.

Directly Imported Cottons.—The following varieties were obtained by the courtesy of the Empire Cotton Growing Corporation: Zululand Hybrid, Improved Bancroft, Watts Long Staple, D & PL No. 6, 4128A–21–32 (from D & PL), Delfos 911 and Express 121. These cottons unfortunately arrived late in the season and could not be planted until the middle of August and early in September. This was much too late to obtain successful results, and the strains will be re-tested. A *herbaceum* cotton from the Plant Breeding Station in Turkestan grew moderately well, but gave a poor yield. One plant was selected and will be grown next season for comparative purposes. Its characteristics are given in Table XII.

Cottons from Kpeve Investigational Station.—Webber and American. Both gave very poor yields and were badly diseased with high shedding. They will be discarded.

Native Cottons.—Ganvelga. This cotton was first found at the village of its name, and its description has not previously been published. The plant is very similar to Ishan; the leaves, however,

are not quite so deeply lobed, the petal spot is not quite so deep a red, and the stems are all very red. The variety is undoubtedly *G. Peruvianum*. This year it has been found growing in the Gambaga district and in several farms near Tamale. It is often mixed with the ordinary native cotton Gummanli, *G. punctatum*, Sch. & Thon. var. *nigerica*. A small sample plot was grown and twelve plants selfed, from which two have been selected for plant-to-row. They are included in Table XII. It will be seen that No. X. 11 has an extraordinary lint length, $1\frac{1}{8}$ by combing and $1\frac{3}{8}$ by paraffin slide. In general the plants were healthy, and the variety is certainly better than Gummanli, as the yields appear to be approximately the same and the cotton is of considerably better quality.

Gummanli.—A small plot from a selected plant was grown, giving a yield per acre of 42.7 lbs. The cotton was harsh and had very low lint length ($\frac{11}{16}$ths by combing), and will be discarded.

Sagai and Kpalagunda (*G. punctatum* and *G. arboreum* Linn. respectively).—These two both failed completely.

(f) Varieties to be Tested in the 1930–31 Seasons.

(i.) Cottons obtained from E. G. G. C. (*see* above).
(ii.) Selected plants from Ganvelga variety.
(iii.) Ganvelga type from Gambaga district.
(iv.) It is hoped to obtain several of the better types of Indian cottons in time for the 1930–31 season.

Discussion :—From the above it will be seen that selection work has now isolated three promising strains, T57, T66 and D28. The last has now had two years in the plant-to-row stage and is naturally more uniform, both in lint and vegetative characteristics, than the other two. It will be seen from Tables II and VIII that the quality of D28 is slightly better than T57 and T66, but it should be possible to isolate from the latter strains, which are much higher yielding, a cotton equally good.

In estimating yields from these strains, it is as yet impossible to say whether those obtained from the very small plots will be reproduced on a field scale. But as, from approximately a 50% stand, D28, T57 and T66 have given 100, 166 and 273 lbs. per acre seed cotton, it would appear reasonable to expect, on a field scale, average yields of approximately 125, 200 and 300 lbs. seed cotton per acre respectively. Either of the last two would be a great increase on any other yield for unmanured cotton yet obtained, and, if maintained, would probably make cotton growing economically attractive to the farmer.

Strains T57 and T66 are still slightly impure, but it has been decided to multiply them rapidly on account of their comparative high yield, whilst purifying selected plants with which to replace them later. In the Northern Territories, yield must be considered

the primary consideration at present, and quality can be improved later. None of these selections has had preferential treatment; indeed the land on which they are grown is below the average.

No other imported variety out of many tried has shown any promise, but the native variety Ganvelga, which is akin to Ishan, seems worth persevering with, as it is of good quality (which cannot be said of any other native variety), and it may be possible to isolate from it a high yielding strain.

PART II.—PHYSIOLOGY AND DISEASE.

(a) Optimum Time of Planting Experiment.

Two varieties of cotton, Allen and Ishan, were planted at five fortnightly intervals, the first planting being on May 31st, 1929, and the last on July 26th, 1929. Each plot was one-twelfth of an acre and each planting was repeated five times, making fifty plots in all, with a total acreage of $4\frac{1}{6}$ acres. The layout was in the form of a Latin square.

The yields are given in Table XIII below :—

TABLE XIII.

YIELDS PER ACRE ON OPTIMUM TIME OF PLANTING EXPERIMENT.

(*Mean of Five Replications.*)

Number.	Planting Date.	Allen.	Ishan.
1st Planting	31/5/29	90.50 lbs.	94.5 lbs.
2nd Planting	14/6/29	93.12 ,,	98.2 ,,
3rd Planting	28/6/29	114.72 ,,	101.3 ,,
4th Planting	12/7/29	111.80 ,,	78.0 ,,
5th Planting	26/7/29	58.00 ,,	66.2 ,,

Owing to great variation among the single plots, very few of the above figures are statistically significant. However, it may be briefly stated that, under the conditions prevailing during the 1929-30 season, the optimum time of planting was during June, with the peak towards the end of June. In the previous season's time of planting experiment, the highest yield was obtained from the July 7th planting (Allen only). It also appears from the figures in Table XIII that it is better to plant slightly earlier rather than slightly later than mid-June–early July.

The physiology and incidence of disease on these plots were studied by means of sample plots. Two plots of one-twelfth of an acre of each planting for both varieties were taken, one set being used to obtain physiological and disease figures, and the other for a stainer index.

On the physiological plots the following figures were taken: flowering, shedding, harvesting and "balance of boll" figures, and the incidence of disease on the shed and harvested bolls was investigated.

Flowering Figures.—These are shown in the form of weekly flowering curves in Graph 1 for Allen and Graph 2 for Ishan. It will be noted that in Allen there are two distinct flowering peaks, the first one occurring during the wet season, the actual date depending upon the time of planting; whilst the second peak occurs during the *harmattan* and is independent of time of planting. It will also be seen that the total number of flowers falls steadily for the later plantings.

Flowers produced during the first peak produce a negligible amount of cotton, as the shedding percentage is extremely high and the incidence of disease on the remaining bolls is also very high. These figures will be given later.

In Ishan, the first peak is very small, and the large peak occurs after the dry season has set in, corresponding to the second peak in Allen. In Ishan, time of planting appears to affect the form of the curve still less than in Allen, and in both varieties climatic conditions play the major part in determining the type of curve.

Shedding.—The curves for shedding follow the form of the flowering curves very closely, with an interval of approximately a week. These curves are given for the third planting of both varieties in Graphs 3 and 4. The shedding percentages of the different plantings are given in Table XIV below. These percentages are calculated on the assumption that the number of shed bolls (including mummied bolls), plus the number of harvested bolls, equal the number of flowers. This give a rather more correct shedding percentage than by using the figures obtained from the flowering counts, as it is found that a certain number of flowers do not open until after 9 a.m.—the time at which flower counts commence—and hence the total flowering figures are too low.

TABLE XIV.

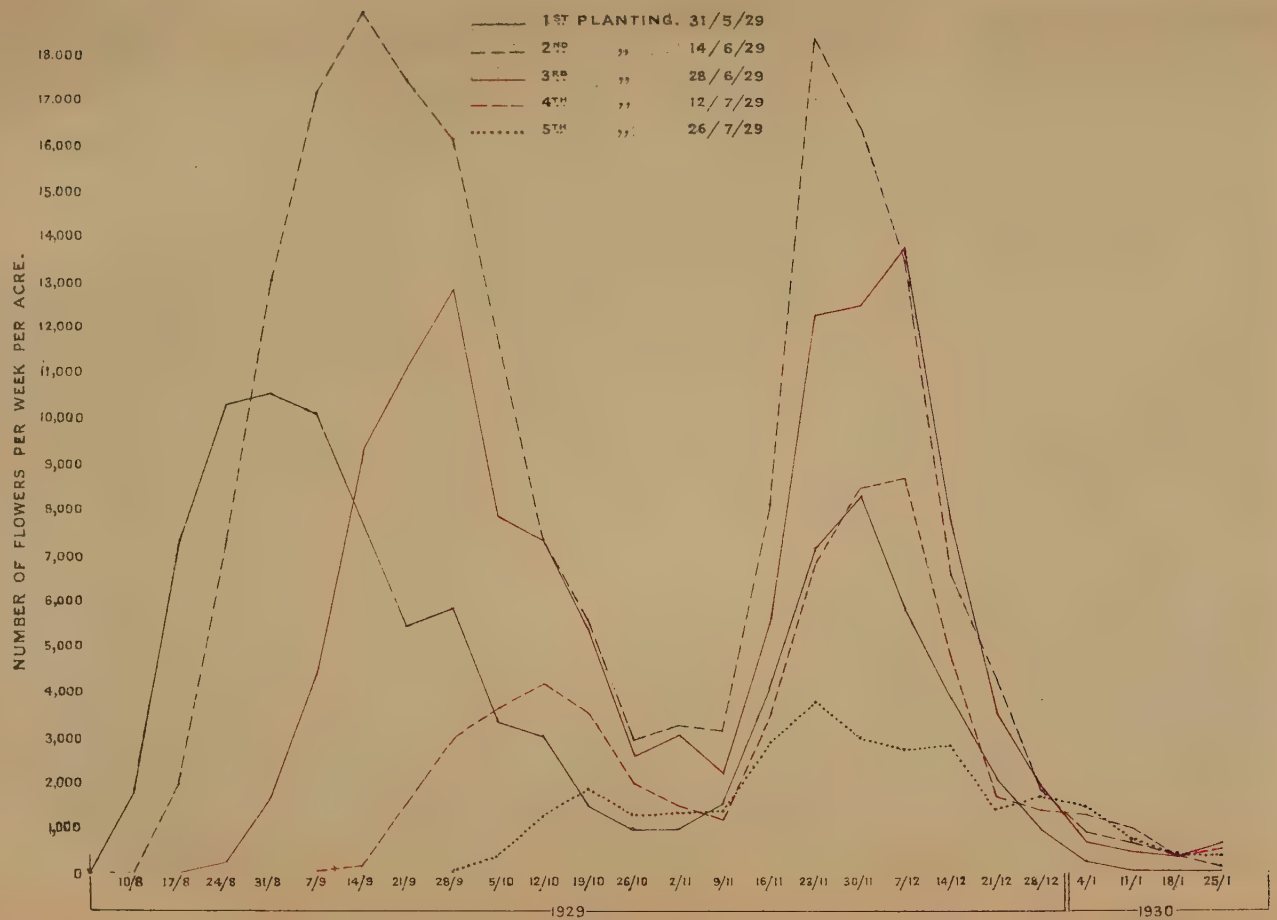
SHEDDING PERCENTAGES. ALLEN AND ISHAN.

Time Planting Experimeut.

	1st Planting.	2nd Planting.	3rd Planting.	4th Planting.	5th Planting.
Allen	82.9	82.1	81.1	86.8	83.7
Ishan	81.2	79.9	78.2	79.9	72.9

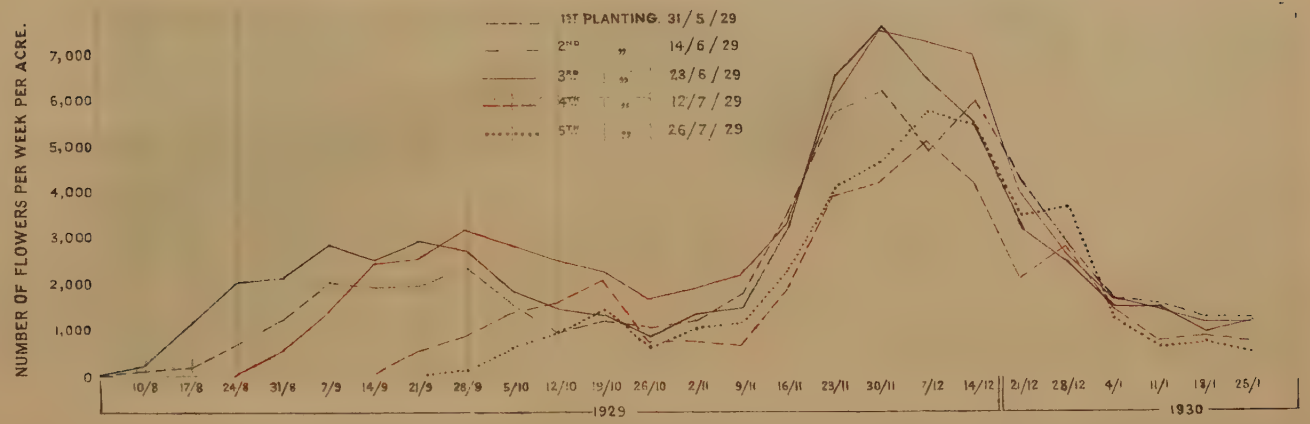
OPTIMUM TIME OF PLANTING EXPERIMENT. FLOWERING CURVES. ALLEN VARIETY.

GRAPH I



OPTIMUM TIME OF PLANTING EXPERIMENT. FLOWERING CURVES ISHAN VARIETY.

GRAPH 2



It will be seen that the shedding percentages are extremely high throughout, and that in Ishan the percentage is slightly lower than in Allen.

The percentage of the total number of shed bolls in each month is also of interest. These figures are given in Tables XV and XVI below.

TABLE XV.

PERCENTAGE OF BOLLS SHED IN EACH MONTH.

Time Planting Experiment. ALLEN VARIETY.

Allen.	1st Planting.	2nd Planting.	3rd Planting.	4th Planting.	5th Planting.
Total number of bolls shed per acre	104,256	184,608	126,912	61,860	33,504
August	13.8	2.5	—	—	—
September ..	28.5	25.7	18.9	3.7	—
October ..	12.9	26.3	21.5	23.9	12.4
November ..	15.2	17.2	16.9	19.6	21.5
December ..	20.8	20.3	29.8	38.4	36.5
January ..	7.4	6.5	11.1	11.0	23.7
February ..	1.4	1.5	1.8	3.4	5.9

TABLE XVI.

PERCENTAGE OF BOLLS SHED IN EACH MONTH.

Time Planting Experiment. ISHAN VARIETY.

Ishan.	1st Planting.	2nd Planting.	3rd Planting.	4th Planting.	5th Planting.
Total number of bolls shed per acre ..	58,572	55,320	65,352	40,688	40,116
August	3.8	0.7	—	—	—
September ..	16.2	13.1	9.9	1.3	—
October ..	11.4	10.3	17.1	9.3	9.8
November ..	15.9	16.7	14.7	18.8	18.6
December ..	32.4	36.6	36.1	37.6	38.4
January ..	16.9	17.8	18.2	27.1	26.1
February ..	3.4	4.7	4.0	5.9	7.1

It will be seen that Ishan sheds considerably later than Allen, as its flowering is also later. The percentages shed in September and October are generally followed by a drop in November and then a

large increase in December, when the result of the second flowering peak is apparent.

Harvested Boll Curves.—These are given for the third week's plantings in Graphs 3 and 4.

The mean period from flowering to ripening of the boll is 44.9 days for Allen, and is approximately the same for Ishan. It will be seen that in the curve for Allen, the first flowering peak which occurs during the rains produces practically no cotton, the considerable number of bolls harvested at the first picking being mainly due to picking being commenced rather late. The peak of the harvesting curve occurs six weeks after the second flowering peak.

In Ishan, where there is only a small flowering peak during the rains, the same effect is seen, and again the peak of the harvesting curve follows seven weeks after the flowering curve. The curves for the remaining plantings follow the above very closely.

"Balance of Bolls" Curves.—The figures for these curves are obtained for each week by subtracting the total number of sheds to that date from the total number of flowers produced to that date, the balance giving an approximation of the number of "potential" bolls remaining on the plants. For Allen third week planting (Graph 3) the curve steadily rises until two weeks after the first flowering peak and then falls, as shedding becomes greater than flowering. This process is then repeated for the second flowering peak, the number of harvested bolls being taken into account.

These curves can be used, especially in the early part of the season, in order to estimate the comparative yields from the different plots.

Incidence of Disease.—All shed bolls were examined and classified as far as possible according to the cause of shedding. (Full details were given in the 1928–29 Report.)

Detailed figures are given in Table XVII.

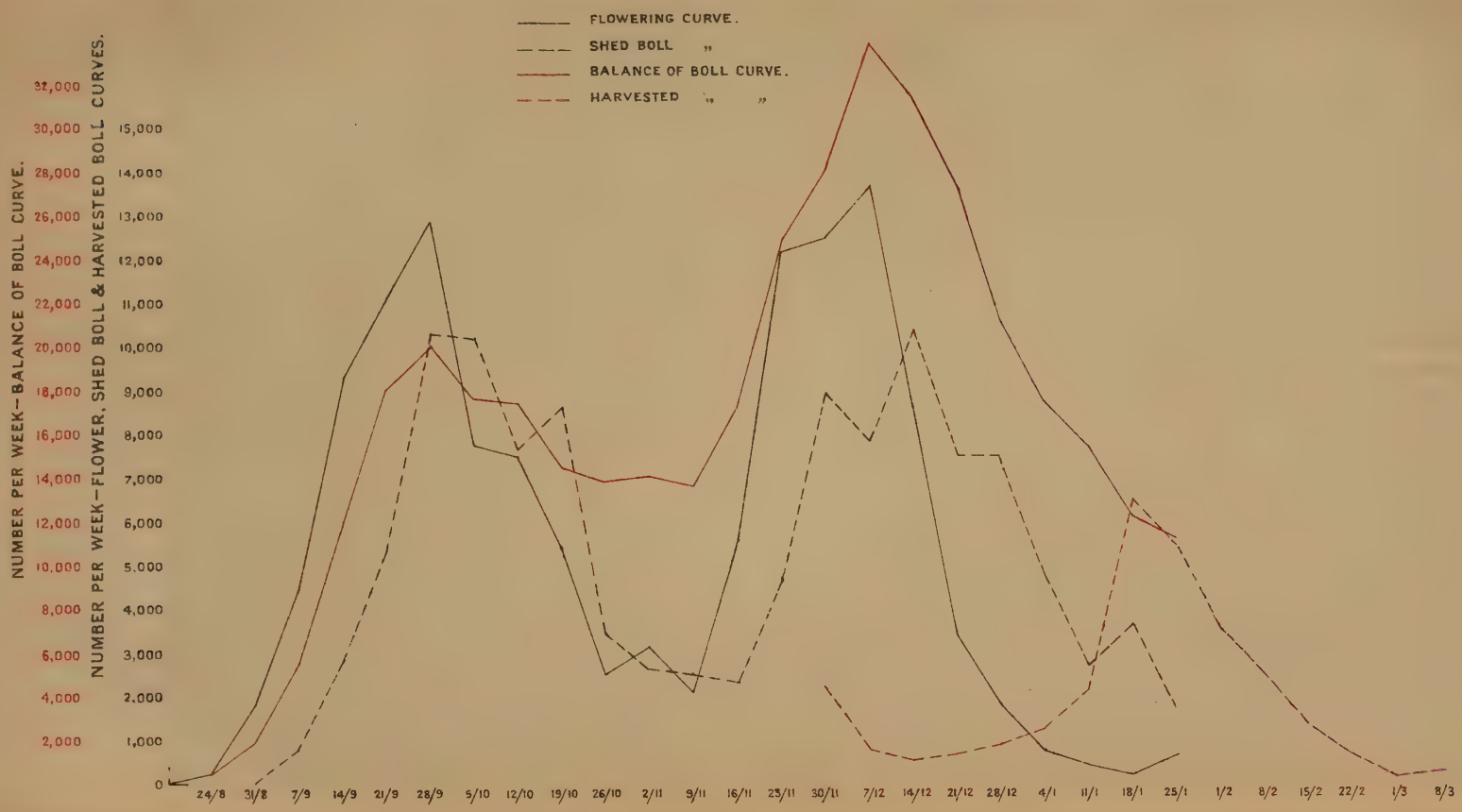
TABLE XVII.

PERCENTAGE OF INCIDENCE OF DISEASE AND INSECT ATTACK IN SHED BOLLS IN THE TIME PLANTING EXPERIMENT.

Allen.	Stainer.	Boll Worm.	Physio-logical.	Other Injuries.	Mummied Bolls.	Per-centages of half-developed Bolls.
1st Planting ..	10.5	23.4	20.6	27.9	17.6	19.5
2nd Planting ..	12.8	22.7	20.5	29.3	14.7	16.5
3rd Planting ..	12.7	24.7	17.4	29.6	15.6	14.6
4th Planting ..	10.9	22.0	20.5	28.7	17.9	14.5
5th Planting ..	10.6	26.0	17.9	23.5	21.9	8.3

OPTIMUM TIME OF PLANTING EXPERIMENT. ALLEN THIRD PLANTING. FLOWERING, SHEDDING, HARVESTED BOLL AND BALANCE OF BOLL CURVES.

GRAPH 3



OPTIMUM TIME OF PLANTING EXPERIMENT. ISHAN THIRD PLANTING. FLOWERING, SHEDDING, HARVESTED AND BALANCE OF BOLL CURVES.

GRAPH 4

TABLE XVII—*continued.*

Ishan.	Stainer.	Boll Worm.	Physio-logical.	Other Injuries.	Mummied Bolls.	Percent-ages of half-developed Bolls.
1st Planting ..	10.5	23.9	19.2	22.8	23.6	—
2nd Planting ..	8.8	23.2	19.4	23.8	24.8	—
3rd Planting ..	11.2	23.1	18.6	24.9	22.2	—
4th Planting ..	10.6	22.9	17.1	20.7	28.7	—
5th Planting ..	10.9	20.8	18.3	24.2	25.8	—

Thus in both varieties the two main causes of shedding are boll worm injury and diseases classified under other injuries. The latter consists largely of various fungoid diseases, a certain proportion of which must be due to damage by stainer attack.

In Ishan the percentage of mummied bolls is consistently higher than in Allen.

Stainer injury accounts for approximately 10% of the total sheds, and hence is not regarded as a major cause of shedding.

The percentage incidence of the different insect and disease attack varies considerably from month to month, but the variation is remarkably constant for the different plantings, *i.e.*, the incidence of disease depends far more upon climatic and seasonal factors than upon time of plantings. The figures for the third week's planting are given in Table XVIII.

TABLE XVIII.

MONTHLY INCIDENCE OF DISEASE AND INSECT ATTACK. PERCENTAGES IN SHED BOLLS. THIRD PLANTING.

Month.	No. of Sheds per Acre.	Stainer.	Boll Worm.	Physio-logical.	Other Injuries.	Mum-mied Bolls.	Percent-ages of half-deve-loped Bolls.
Allen.							
September ..	24,060	13.1	23.4	26.3	36.5	—	31.6
October ..	27,168	14.3	17.4	22.6	44.6	0.9	17.2
November ..	21,540	15.0	31.8	7.7	28.2	17.3	10.8
December ..	37,616	10.9	26.5	15.9	27.6	19.1	9.0
January ..	13,992	11.9	18.7	16.0	5.4	48.0	3.7
February ..	2,376	9.1	9.6	3.6	—	77.7	—
Ishan.							
September ..	6,504	15.6	19.6	34.3	30.1	—	—
October ..	11,172	11.9	21.5	23.6	42.2	0.8	—
November ..	9,588	12.4	35.9	10.4	31.2	10.1	—
December ..	23,580	9.9	21.0	19.4	26.5	23.1	—
January ..	11,892	11.3	21.0	13.7	3.6	50.3	—
February ..	2,616	9.7	16.3	0.3	—	72.7	—

TABLE XXI.

Monthly Lock Analysis of Harvested Bolls.

Third Plantings.

	No. of Bolls per Acre harvested.	Percentage of					Actual Weight of Seed Cotton per Acre. lbs.
		Useless Bolls.	Bolls with two or less Locks developed.	Bolls slightly damaged or stained.	Clean Bolls.	Bolls with Boll Worm Injury.	
Allen.							
November ..	2,148	57.4	32.9	8.4	1.3	87.7	0.6
December ...	3,756	40.6	31.6	14.0	13.8	49.2	6.2
January ..	17,532	4.6	21.9	47.5	26.0	54.5	112.7
February ..	4,992	2.7	18.0	50.0	29.3	43.3	43.9
Ishan.							
November ..	588	57.2	38.8	4.0	—	63.3	0.4
December ..	2,796	24.9	32.6	28.3	14.2	66.1	2.4
January ..	8,652	0.6	30.6	44.8	24.0	46.9	44.4
February ..	6,192	9.5	21.3	37.0	32.2	47.1	51.0

Discussion.—Among the most important conclusions that can be drawn from the above study of the physiology and the incidence of disease on these two varieties are the facts that bolls which set before about the beginning of November contribute practically nothing to the yield. There are two main causes for this :—

1. During the wet season there is excessive shedding, due probably to a very high humidity and waterlogging of the soil.

2. The extremely high percentage of damage on the bolls harvested in November and December.

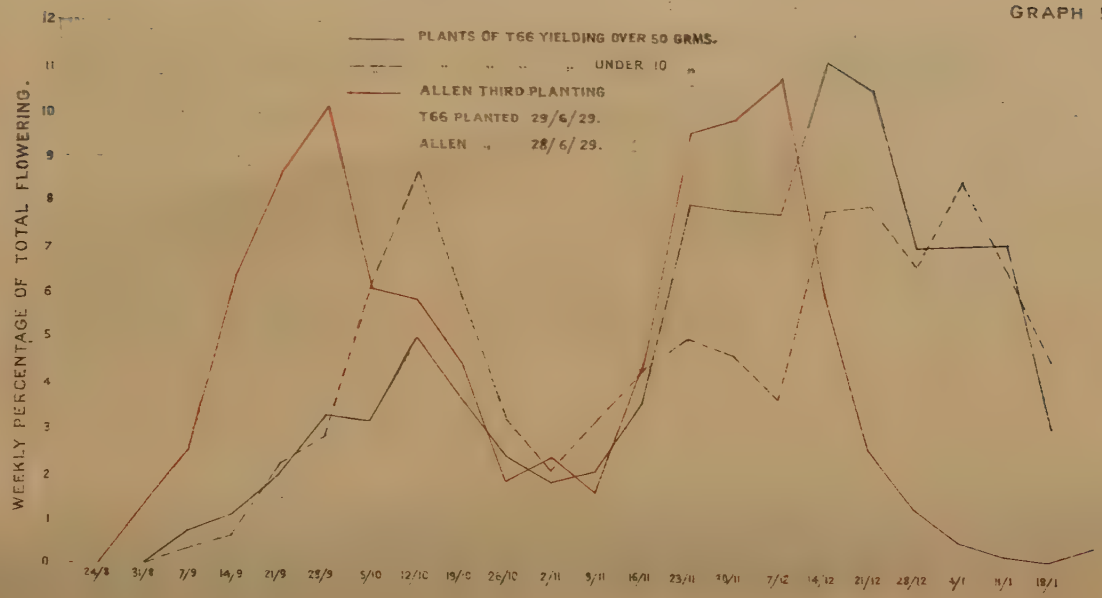
It also appears that the production of bolls mainly in January and February cannot be economically achieved by late planting, as seasonal conditions are then unsuited to the development of the plant and a low yield again results.

The Ishan variety seems physiologically unsuited to the Northern Territories, which bears out Northern Nigerian experience. Here, though the bulk of the flowering takes place at the optimum time for yield and the shedding percentage is less than Allen, yet the ultimate yield per acre is lower. The plants are straggling, and it is considered very doubtful whether selection among this variety will lead to high yields being obtained.

The most likely means of obtaining a high yielding variety thus appears to be to select, from among the American types, a strain that has a long vegetative period—to obtain a well-developed plant before the dry season commences and then a rapid flowering season.

WEEKLY FLOWERING OF STRAIN T66. AND ALLEN THIRD PLANTING,
EXPRESSED AS A PERCENTAGE OF TOTAL FLOWERING.

GRAPH 5



Selection has been carried out on these lines for the past two seasons, and the results obtained from the two high yielding strains T66 and T57 appear to bear out the above considerations.

In Graph 5 the flowering curves of T66 are given as follows :—

That of the twenty-one plants yielding over 50 gms. of seed cotton is given as one curve and that of the twenty-nine plants yielding under 10 gms. as another curve.

The curve for Allen third planting is also given. In all cases the weekly flowering is given as a percentage of the total flowering during the season.

It will be seen that, in the curve for the high yielding plants of T66, only a small peak occurs during the wet season and that the main flowering (73.7% of total) occurs from the middle of November to the middle of January, *i.e.*, the optimum time. In the low yielding plants of T66, the peak in the wet season is considerably larger and the second flowering peak is very straggling, reaching a maximum in January, when the bolls set have little chance of reaching maturity owing to the extreme aridity of the climate at this time of the season. This is still more emphasised when the curve for Allen third planting—approximately the same planting date—is considered. Here the first peak is nearly as large as the second and crop-yielding peak. The percentage of flowers after the middle of November being only 46.3 of the total flowering, hence more than half of the flowering period is completely useless as regards production of cotton.

Stainer (Dysdercus) cannot be considered a serious pest, but boll worm, which causes over 20% of shedding and is responsible for attacking approximately 50% of harvested bolls, must be classed as a major pest. Fortunately, in the type of cotton it is sought to obtain, with a flowering period from mid-November–mid-January, boll worm is at that time on the decline (and attack before that time will have negligible results), but is still high, and, obviously, remedial measures will have to be taken against this pest.

(b) Manurial Experiment.

Two treatments were tried: (*a*) Green manure with Bengal beans. These were planted on April 11th, 1929, but failed owing to lack of rain. A second planting on May 14th, 1929, was successful. The plants were dug in on July 8th. (*b*) Pen manure. This was applied immediately before planting at the rate of 11 tons per acre. In addition, control plots were planted and both Allen and Ishan varieties tested. Each series of plots was repeated four times, the plots being laid out as a Latin square. Each plot was one-eleventh of an acre. All cotton was planted on July 12th. Yields are given in Table XXII.

TABLE XXII.

YIELDS IN MANURIAL EXPERIMENT (LBS. PER ACRE OF SEED COTTON).

Means of Four Replications.

Plots.	Allen.	Ishan.
Control	74.8	64.4
Bengal beans	66.3	57.4
Pen manure	154.0	143.6

The large increase of yield with pen manure is undoubtedly statistically significant in both varieties.

The green manurial treatment gave a slightly smaller yield than the control, but this difference is not significant.

This test of green manuring was hardly conclusive, however, as the green manure was dug in only four days before planting, and hence did not have time to break down properly.

For the above reason, and as the yields are so similar to the control plots, the Bengal bean plots will not be further discussed.

The physiology and disease incidence was studied by means of sample plots and the results are given below.

The flowering, shed boll and harvested boll curves are given in Graph 6 for Allen and Graph 7 for Ishan.

It will be seen that the types of curves are very similar for the manured and unmanured plots in both cases, the main difference being one of volume.

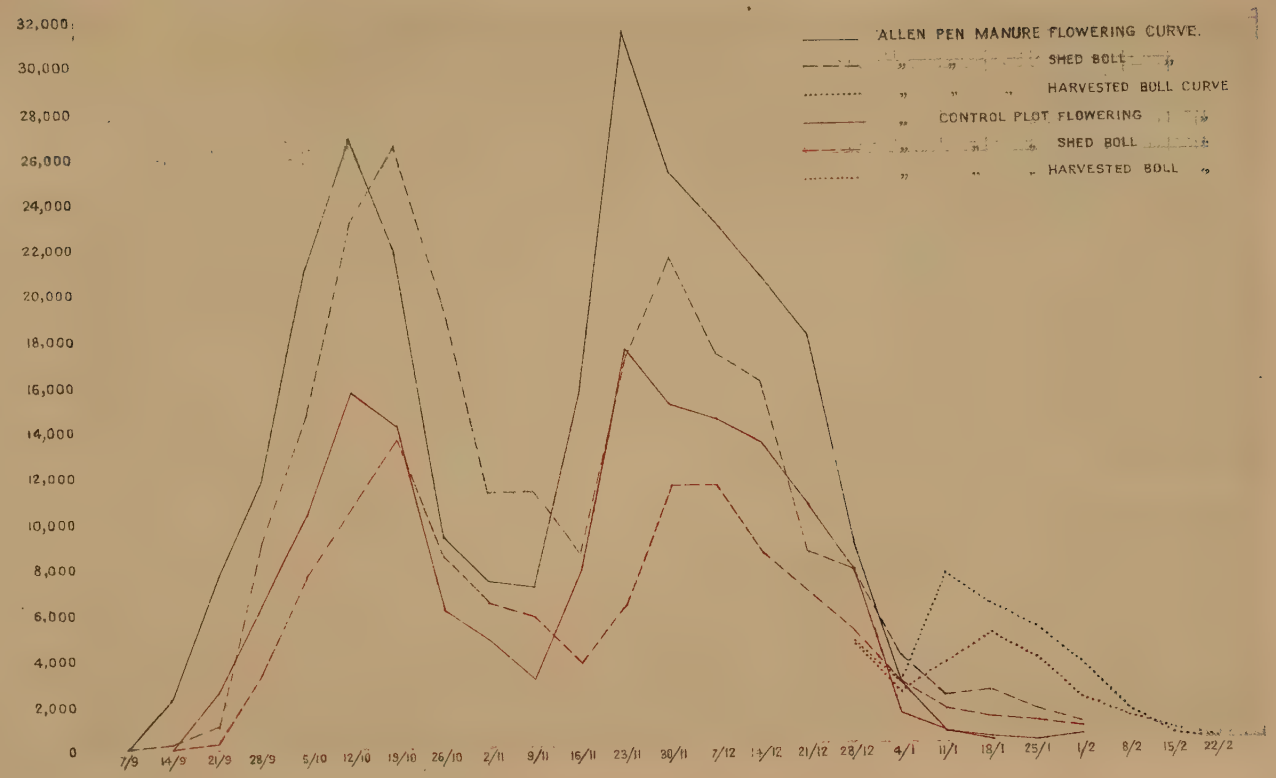
The manure stimulated flower production enormously, especially in Allen—one week 31,000 flowers per acre were produced in the manured Allen plot.

These curves also correspond very closely to the fourth planting curves in the time experiment. (In comparing the two sets of curves it must be noted that in Graphs 6 and 7 the vertical scale is only half that of the time planting curves.)

The shedding percentages are given in Table XXIII below.

MANURIAL EXPERIMENT. ALLEN. FLOWERING.
SHED BOLL, AND HARVESTED BOLL CURVES.

GRAPH 6



MANURIAL EXPERIMENT. ISHAN. FLOWERING.
SHED BOLL. AND HARVESTED BOLL CURVES.

GRAPH 7

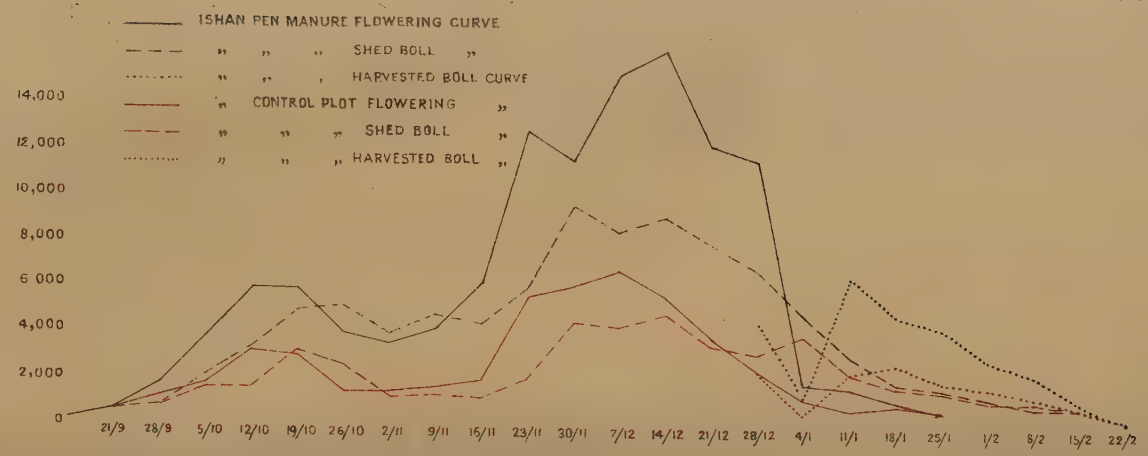


TABLE XXIII.

Shedding Percentages.

Manurial Experiment.

	Allen.		Ishan.	
	Total Number of Sheds per Acre.	Shedding Percentage.	Total Number of Sheds per Acre.	Shedding Percentage.
Pen manure ..	228,932	88.9	91,542	78.2
Control ..	119,130	84.6	47,883	79.5

Thus pen manure increases the yield merely by increasing the number of flowers, and not by increasing the resistance of the plants to shedding.

The monthly incidence of shedding, however, is rather different to the fourth planting in the time planting experiment. Detailed figures are given in Table XXIV below.

TABLE XXIV.

Percentage of Bolls Shed in each Month.

Manurial Experiment.

Month.	Allen.		Ishan.	
	Manure.	Control.	Manure.	Control.
September	6.5	4.6	1.2	2.6
October	39.3	37.2	21.6	19.8
November	26.9	24.0	28.2	19.9
December	22.3	28.4	38.4	37.8
January	4.4	4.8	9.3	16.7
February	0.6	1.0	1.3	2.8

It will be seen that in all these plots a larger percentage of the total shedding occurs in the first three months than in the corresponding time planting experiment. This is probably largely due to soil differences. However, among the manurial plots themselves, there does appear in Allen cotton to be a definite tendency for a higher percentage to be shed during the earlier months, *i.e.*, that flower production, and hence shedding, is proportionately greater in these months, when pen manure is applied.

Incidence of Disease.—Details of disease and insect attack on shed bolls are given in Table XXV below.

TABLE XXV.

PERCENTAGE INCIDENCE OF DISEASE AND INSECT ATTACK IN THE MANURIAL EXPERIMENT.

	Stainer.	Boll Worm.	Physio-logical.	Other Injuries.	Mummied Bolls.	Percent-age of half-developed Bolls.
Allen.						
Pen manure ..	15.3	23.4	20.4	32.7	8.2	12.4
Control	13.7	23.2	19.9	33.7	9.5	12.2
Ishan.						
Pen manure ..	12.4	24.5	19.4	28.2	15.5	11.1
Control	10.8	24.0	18.7	24.3	22.2	8.8

Thus in both varieties incidence of disease is very similar for manured and unmanured plots. It was rather to be expected that in the manured plots the plants would be healthier and that physiological shedding, at least, would be less than in the control plots. However, in both varieties there is no significant difference for physiological shedding.

When the disease incidence figures are compared with the corresponding planting in the time experiment (fourth planting) it will be seen that in Allen especially stainer attack is higher in the manurial plots, as are "other injuries," whilst mummied bolls are considerably lower.

Lock Analysis.—Detailed figures are given in Table XXVI below.

TABLE XXVI.

LOCK ANALYSIS OF HARVESTED BOLLS (OPEN BOLLS ONLY).

Manurial Experiment.

	No. of Bolls per Acre har-vested.	Percentage of				
		Useless Bolls.	Bolls with two or less Locks de-veloped.	Bolls slightly damaged or stained.	Clean Bolls.	Bolls with Boll Worm Injury
Allen.						
Pen manure ..	30,107	7.0	37.7	32.2	23.1	58.9
Control	21,385	5.4	29.6	40.5	24.5	59.0
Ishan.						
Pen manure ..	25,432	4.9	32.5	41.3	21.3	55.7
Control	11,649	10.0	25.4	39.2	25.4	53.3

These figures are again very similar for manured and unmanured plots, and also are comparable with the figures in the time planting experiment.

Discussion.—The pen manured plots gave an increase of 100% over the control plots.

From a study of the physiology and disease and insect attack figures, it is clear that this increase in yield is brought about by increase in the number of flowers, and that it is not due to the increased resistance to shedding, whether physiological or caused by insect or fungoid damage.

PART III.—ROTATION EXPERIMENT AND OUT-STATION WORK.

(a) Rotation Experiment.

A five-course rotation experiment was laid down during the 1929-30 season. The crops consisted of yams, legumes, cotton, guinea corn and maize and groundnuts. Each plot was one-tenth of an acre and there were five replications of each planting.

Allen was the variety of cotton used in the experiment and was planted on June 29th, 1930, *i.e.*, corresponding to the third planting in the time planting experiment.

A very good stand was obtained. The yields on the different plots were extremely variable (from 128 lbs. per acre to 215 lbs. per acre), and a mean yield of 157.6 lbs. per acre of seed cotton was obtained.

The usual figures were taken on a sample plot. These, however, correspond very closely with Allen third planting and will not be further discussed.

(b) Observation Plots at Outstations.

One-acre plots of the Ishan variety were grown at Lorha, Navrongo, Gambaga, Salaga, Kratchi and Wa. The last two were failures. Of the others none yielded more than 136 lbs. seed cotton per acre (Navrongo), the others being 70 lbs., 36 lbs., and lbs. No figures of physiology or disease incidence could be taken on these far-distant stations, and the yield is not considered sufficiently promising to persevere with this variety in bulk.

TABLE II.

Characteristics of Selected Plants of Strain D28.

Plant No.	Total No. of Bolls.	Mean Weight per Boll (gms.).	Average No. of Lock per Boll.	Weight of Seed Cotton (gms.).	Lint Length.	Type of Seed.	Ginning %	Cotton.		Vegetative Characteristics.			
								Strength.	Texture.	Height.	Health.	Maturity.	Miscellaneous.
D28/16	20	3.3	3.8	53.9	15.05	Fuzzy	33.5	5	Medium silky	3′ 0″	Good	Very late	Very good type. Bushy.
D28/23	26	3.1	3.5	75.0	15.03	Fuzzy	31.9	6	Medium silky	3′ 0″	Good	Late	Very good. Excellent bolls.
D28/30	11	2.3	3.7	25.8	16.52	Fuzzy	32.1	5	Medium silky	2′ 6″	Good	Medium	Fair type.
D28/66	14	3.6	3.6	44.9	15.58	Fuzzy	30.8	7	Silky	2′ 6″	Good	Late	Good type. Bushy
D28/77	10	2.2	3.7	18.8	16.64	Fuzzy	33.3	8	Silky	3′ 0″	Fair	Medium	Good type.

CHARACTERISTICS OF PLANTS FROM 1928–29 SELECTIONS, SELECTED FOR SOWING IN PLANT-TO-ROW FOR THE 1930–31 SEASON.

Both Strains planted June 29th, 1929.

Plant No.	Total No. of Bolls.	Mean Weight per Boll. gms.	Average Locks per Boll.	Weight of Seed Cotton gms.	Lint Length 1/16ths.	Type of Seed.	Ginning %	Total No. of Flowers.	Shedding.	Maturity.	Cotton.		Vegetative Characteristics.	
											Texture.	Strength.	Height.	Miscellaneous.
T57/49	12	3.9	3.5	42.5	16.15	Semi-fuzzy	36.2	94	87.3	Late	Medium silky	5	3′ 6″	Very vigorous. Medium type.
T57/50	14	4.0	4.0	51.2	15.08	Fuzzy	33.2	86	83.7	Late	Medium	8	3′ 6″	Large bolls. Very good type.
T57/68	5	3.6	4.0	15.0	13.92	Smooth	39.3	—	—	Very late	Medium silky	5	2′ 6″	Good bolls. Medium type.
T57/73	33	3.2	3.8	88.2	15.04	Fuzzy	35.6	167	70.3	Late	Medium	4	3′ 6″	Good bolls. Excellent type.
T57/118	24	4.1	3.8	91.1	14.45	Semi-fuzzy	33.6	192	87.5	Medium late	Medium silky	5	3′ 6″	Very vigorous. Good type.
T57/122	15	3.5	3.7	44.7	15.85	Smooth	32.9	66	77.3	Medium late	Silky	6	3′ 0″	Good type.
T57/140	9	5.7	4.1	47.0	15.18	Fuzzy	34.9	52	82.2	Late	Medium silky	6	3′ 6″	One boll weighed 7.4 gms. Very good type.
T57/150	22	2.8	3.5	55.3	14.96	Smooth	37.4	49	54.3	Late	Medium silky	5	3′ 0″	Medium type.
T66/40	17	3.4	4.0	55.2	15.08	Fuzzy	33.2	50	66.0	Very late	Medium silky	6	3′ 0″	Good bolls. Good type.
T66/56	36	2.9	4.0	96.1	14.29	Smooth	31.5	128	71.9	Late	Medium silky	5	3′ 6″	Good bolls. Very good type.
T66/57	28	2.3	3.7	60.4	14.34	Smooth	32.6	105	73.3	Early	Medium silky	6	4′ 0″	Medium type.
T66/59	41	3.2	4.3	113.0	15.36	Smooth	28.6	139	70.6	Very late	Silky	5	4′ 6″	Good bolls. Very good type.
T66/126	17	3.9	4.1	60.0	15.17	Fuzzy	31.3	49	65.3	Late	Medium	4	3′ 0″	Good bolls. Good type.
T66/131	17	3.5	3.8	50.4	14.75	Smooth	30.7	51	66.7	Late	Medium silky	4	3′ 0″	Good type.
T66/133	15	3.9	3.7	51.5	15.17	Fuzzy	36.1	63	76.2	Late	Silky	4	3′ 6″	Excellent bolls. Good type.
T66/141	25	3.9	4.1	89.5	15.56	Fuzzy	32.3	83	69.9	Very late	Medium silky	3	3′ 6″	Excellent plant. Very vigorous.
T66/144	30	3.2	3.8	80.9	14.89	Smooth	27.7	128	76.6	Late	Medium silky	3	3′ 0″	Good type. Bushy.
T66/147	21	3.2	3.8	55.8	15.04	Smooth	30.3	71	70.2	Late	Silky	3	3′ 0″	Very good type. Good bolls.

TABLE IX.

Characteristics of Parents of Strains T57, T66, T75, T68 and D28.

Plant No.	Variety.	Total No. of Bolls.	Mean Weight per Boll. gms.	Average No. of Locks per Boll.	Weight of Seed Cotton.	Lint Length.		Type of Seed.	Ginning %	Cotton.		Vegetative Characteristics.		
						Combing.	Paraffin Slide.			Strength.	Texture.	Height.	Health.	Miscellaneous.
T57	Allen Smooth	31	3.77	3.97	98.0	15.36	18.45	Smooth	33.20	8	Silky	3′ 0″	Medium	Very good type.
T66	Ashanti Smooth	100	2.67	4.02	243.7	14.99	17.31	Smooth	28.24	7	Medium silky	5′ 0″	Very good	Very late maturing. Excellent type.
T75	Allen	14	4.74	4.0	66.2	15.58	18.78	Fuzzy	32.40	8	Silky	3′ 0″	Good	Large bolls. Very well shaped.
T68	Allen	46	3.87	4.0	127.7	15.54	18.18	Fuzzy	27.35	7	Medium lky	3′ 0″	Very good	Bushy. Late maturing.
D28	Allen	42	2.90	4.0	99.7	14.61	17.41	Fuzzy	30.0	6	Medium silky	4′ 6″	Very good	Excellent plant

TABLE X.

Characteristics of Plants from T68 and T75 Strains.

Plant No.	Total No. of Bolls.	Mean Weight per Boll gms.	Average No. of Lock per Plant.	Weight of Seed Cotton. gms.	Lint Length.	Type of Seed.	Ginning %	Cotton.		Vegetative Characteristics.			
								Strength.	Texture.	Height.	Health.	Maturity.	Miscellaneous.
T68/48	14	3.1	3.9	41.8	14.78	Smooth	34.9	5	Silky	3′ 0″	Very good	Late	Good.
T68/94	24	4.2	3.9	94.6	15.40	Smooth	31.1	6	Medium silky	3′ 6″	Very good	Very late	Bolls well distributed. Excellent.
T68/108	20	3.3	4.0	56.9	15.15	Semi-fuzzy	30.4	6	Medium silky	3′ 0″	Fair	Late	Well shaped.
T75/70	13	3.1	4.1	33.7	14.59	Fuzzy	35.0	7	Silky	3′ 0″	Good	Late	Good shape.
T75/174	12	2.9	4.0	28.5	14.97	Semi-fuzzy	34.1	6	Silky	4′ 0″	Good	Late	Good shape.
T75/175	18	2.4	4.2	43.6	15.12	Fuzzy	37.0	5	Silky	3′ 6″	Good	Very late	Well shaped.

TABLE XI.

Characteristics of Field Selections to be Grown on Plant-to-row Method next Season.

No. of Plant.	Variety.	Total No. of Bolls.	Mean Weight of Cotton per Boll.	Average No. of Locks per Boll.	Weight of Seed Cotton.	Lint Length.		Ginning %	Type of Seed.	Cotton.		Vegetative Characteristics.			
						Combing.	Paraffin Slide.			Strength.	Texture.	Height.	Health.	Maturity.	Miscellaneous.
S30	Allen	34	3.2	4.0	86.5	14.12	17.14	37.9	Fuzzy	4	Medium silky	3′ 0″	Very good	Late	Very large leaves and circular bolls.
S35	Allen	70	3.6	4.1	223.2	13.95	16.66	34.5	Fuzzy	5	Medium silky	4′ 6″	Very good	Very late	Promisory plant. Good bolls.
S41	Allen	82	4.7	3.9	320.5	15.12	18.42	34.1	Fuzzy	6	Medium	5′ 0″	Very good	Late	Very fine plant. Bushy. Large leaves.
S22	Ishan	105	2.9	3.1	264.5	15.0	17.6	33.4	Smooth	6	Medium harsh	10′ 0″	Very good	Late	On highly manured ground. Rather straggly.
S25	Ishan	88	2.3	3.1	187.7	15.07	17.72	31.9	Smooth	9	Medium harsh	6′ 0″	Very good	Medium late	Small bolls. On very good ground.
F12	Ishan	18	1.6	3.2	25.1	17.35	—	34.0	Smooth	5	Silky	4′ 0″	Good	Late	Medium type.
S15	Hybrid	28	3.3	3.0	82.6	17.74	20.82	33.0	Smooth	5	Silky	4′ 0″	Very good	Medium late	Very vigorous. Good bolls, near Ishan.
S17	Hybrid	115	2.7	3.7	349.5	16.26	19.10	31.2	Fuzzy	6	Medium silky	6′ 0″	Very good	Medium late	Large green seeds. Manured ground. Ishan bolls. Very red stem.
S19	Hybrid	166	2.5	3.3	357.5	16.35	19.86	32.6	Smooth	5	Medium	7′ 0″	Very good	Medium late	Straggly. Near Allen. Manured ground.
S21	Hybrid	216	2.3	3.6	423.8	16.39	19.1	30.0	Smooth	4	Medium silky	12′ 0″	Good	Medium late	Medium type. Near Ishan. Manured ground.
S33	Hybrid	112	2.6	3.5	233.1	14.27	17.34	29.9	Smooth	8	Silky	6′ 0″	Very good	Late	Very near Ishan.
S39	Hybrid	29	3.9	3.9	99.6	14.26	17.86	39.3	Fuzzy	4	Medium	2′ 6″	Very good	Late	Good, rather large basal branches.
S44	Hybrid	32	4.1	4.2	123.5	14.71	18.3	34.3	Smooth	5	Medium silky	5′ 0″	Very good	Very late	Very good plant. Large bolls. Near Allen.
S56	Hybrid	53	2.7	3.4	136.0	16.58	19.08	35.0	Fuzzy	5	Silky	5′ 6″	Very good	Late	Good plant.
S31	?	54	1.5	3.5	77.0	11.01	—	30.2	Smooth	4	Medium silky	3′ 6″	Very good	Late	See description in text.

TABLE XII.

Characteristics of Cottons tested in 1929–30 Season.

Plant No.	Variety.	Total No. of Boll.	Mean Weight per Boll.	Average No. of Locks per Boll.	Weight of Seed Cottons. lbs.	Lint Length.		Type of Seed.	Ginning %	Cotton.		Height.	Health.	Maturity.	Miscellaneous.
						Combing	Paraffin Slide.			Strength.	Texture.				
O.6	Herbaceum	5	2.6	4.0	12.8	13.62	—	Fuzzy	30.7	3	Medium silky	3′	Good	Medium	—
X.11	Ganvelga	13	1.6	3.2	18.6	18.22	21.9	Fuzzy	31.5	7	Very silky	3′	Good	Late	Fuzzy, very green.
X.23	Ganvelga	31	1.3	3.0	34.8	15.10	—	Smooth	27.5	7	Silky	3′	Good	Late	Small bolls.

PART IV.—SUMMARY AND RECOMMENDATIONS.

1. Three strains showing distinct promise have now been isolated. They are of American type. One is nearly pure, with a medium yield of good quality lint, and two are slightly impure in their seed characteristics, but have yields which, if maintained on a field scale, would make cotton growing economically attractive to the farmer. They are also of good quality, but as yield is paramount, priority must be given to that character before quality.

2. No other introduced type of cotton gives promise, and one native type alone, Ganvelga, appears worth persevering with.

3. It is now established that there is practically no yield from bolls which set before early November. The cause is climatic and is due to extreme shedding, owing to excess moisture in the height of the rains (August and September) and to a high percentage of insect attack on such bolls as do remain.

4. A type of cotton is wanted which makes a well-developed plant before the dry season commences and then a rapid flowering season. (Late planting will not produce this type.) The higher yielding plants of the strain T66 approach this ideal type.

5. Boll worm must be considered a major pest, but stainer is not serious.

6. Manurial experiments, though giving double the yield of control plots, show that this is not due to increased resistance to shedding, but to the fact that flower production and size of plant is greatly stimulated.

7. The Ishan variety seems physiologically unsuited to the district, and it is considered that selection work is not likely to produce a good strain of this type.

8. It is recommended that attention in the coming season be concentrated on the three promising strains and on testing new varieties, and that no more field-scale trials be undertaken at present. Also that out-station work on this crop be discontinued till sufficient seed of some selected strain is available for trial.

9. Measures against boll worm must be commenced in the coming season, as this pest is a limiting factor in high yield.

10. Artificial manures will be tried in the coming season to ascertain whether any soil deficiency in minerals is shown.

PAPER No. XXXVII.

COTTON TRIALS, KPEVE, 1928–29.

SUMMARISED BY H. K. HEWISON.

During 1928, 20 acres were devoted to cotton trials and information sought on the following four points :—

(1) The relative merits, under local conditions, of Sonko and Ishan varieties. Sonko being a local cotton and Ishan a cotton of Nigerian origin.

(2) The most favourable period for cotton planting in the district.

(3) The most economic planting distance under 12 square feet.

(4) The comparative values of ridge and flat planting.

The area selected was a well-drained flat, where gravel exists at varying depths beneath the fairly light surface soil.

A portion of the land had carried cotton previously, and the greater part had been used by local inhabitants for food growing some years before.

After clearing, the ground was prepared normally, and weeds and succulent growths were dug in during digging. Ridged areas did not receive a preliminary forking, but care was taken to break up the soil of the strips on which ridges were being formed.

LAYOUT OF THE AREA.

The 20 acres were divided into four 5-acre blocks ; 10 acres, or two blocks, being devoted to

(*a*) Sonko-Ishan variety comparison, and
(*b*) Optimum planting period test ;

and the second 10 acres to

(*a*) Ridge and flat planting comparison, and
(*b*) Optimum planting distance.

Each block comprised twenty adjacent strips of one-quarter acre each, each strip or plot measuring 20 chains by one-half chain. Each 10-acre investigation, therefore, was based on the yields of forty one-quarter acre plots.

The width between the rows, 4 feet, was constant throughout the area, and each stand uniformly composed of two plants.

Three planting dates, with intervals of a fortnight, were on trial: June 30th, July 15th and July 31st; and the three planting distances examined were: 4 feet by 3 feet; 4 feet by 2 feet; 4 feet by 1 foot.

The detail of plot arrangement is explained by the accompanying plan.

Harvesting commenced on December 21st, 1928, and continued until March, 1929.

RESULTS.

For the 20 acres the total yield was .. 3,850 lbs. seed cotton.
The average yield per acre .. .. .. 192.5 ,, ,,

A bag containing 50 lbs. seed cotton was stolen prior to ginning. Ginning out-turn was 31.6%.

Reports from brokers concerning marketing qualities are not yet to hand.

With regard to the four principal objects of the investigation the following figures were obtained. The sources of the yields quoted may be seen in the detailed tables in the Appendix.

Edge-effect plots are excluded from all yield records.

I. Sonko and Ishan Varietal Comparison.

	Sonko.	Ishan.	Difference in favour of Ishan.
	lbs.	lbs.	lbs.
Total yield	724.5	837	112.5
Average plot yield	40.25	46.5	6.25
Average yield per acre ..	161	186	25

Of the eighteen pairs of adjacent plots, twelve yields were in favour of Ishan, five in favour of Sonko and one was equal.

II. The Optimum Planting Period.

VARS. SONKO AND ISHAN.

Date of Planting:—	June 30th.	July 15th.	July 31st.
	lbs.	lbs.	lbs.
Total yield of plots	550	502	509.5
Average yield of plots ..	45.8	41.8	42.4
Average yield per acre ..	183.2	167.3	169.8

The superiority of the yield from the earliest planted cotton is attributable, in all probability, to favourable rains which followed sowing and enabled the seedlings to get away well. The second sowing was followed by four weeks of comparative rainlessness, and the seedlings of both this and the third sowing showed obvious signs of water shortage.

III. The Most Economic Planting Distance.

VAR. SONKO.

Planting Distance:—	4′ × 3′	4′ × 2′	4′ × 1′
	lbs.	lbs.	lbs.
Total plot yield	610.5	640.5	601.5
Average plot yield	50.9	53.4	50.1
Average yield per acre ..	203.6	213.6	200.4

Varying the distance of planting from 4 square feet to 12 square feet made no appreciable difference to the yield.

IV. The Comparative Values of Ridge and Flat Planting.

VAR. SONKO.

	Ridged.	Flat.
	lbs.	lbs.
Total yield	915	937.5
Average plot yield	51	52
Average yield per acre	203	208

It would appear from these results that no advantage was derived from ridging under the conditions of this experiment.

SUMMARY.

I. There is an indication that Ishan, the imported variety, is slightly superior to Sonko in yielding powers.

II. Early planting appears to be superior to later. The possibility that the optimum planting period may be earlier than the earliest date examined (June 30th) is being examined in the 1929–30 trials.

III. There is no advantage in yield in planting these cottons closer than one stand of two plants per 12 square feet.

IV. The value of conserving moisture and preventing erosion by employing ridges as opposed to planting on the flat is not apparent in the first year of trials.

APPENDIX.

Total yield (20 acres) .. .. .. 3,850 lbs. seed cotton.
Average yield .. .. 192.5 ,, ,,

Detailed Results. (All in seed cotton).

BLOCKS A AND B. VAR. SONKO.

Spacing :—	4′ × 3′		4′ × 2′		4′ × 1′	
	Ridge.	Flat.	Ridge.	Flat.	Ridge.	Flat.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	45.0	46.0	68.0	64.0	76.0	44.6
	50.0	52.0	65.0	36.5	29.5	64.5
	54.5	77.0	77.0	65.0	54.5	61.5
	44.5	41.5	51.5	52.0	52.0	42.5
	36.5	39.5	38.0	34.5	39.0	37.5
	54.0	70.0	39.0	50.0	41.0	59.0
Total yields	284.5	326.0	338.5	302.0	292.0	309.5

(1) Total yield of ridge plots = 915 lbs. equiv. of 203 lbs. per acre.
,, ,, flat ,, = 937.5 ,, ,, 208 ,, ,,
(2) Total yield of plots 4′ × 3′ = 610.5 lbs. equiv. of 203 lbs. per acre.
,, ,, 4′ × 2′ = 640.5 ,, ,, 213 ,, ,,
,, ,, 4′ × 1′ = 601.5 ,, ,, 200 ,, ,,

BLOCKS C AND D.

Planting Date :—	30/6/28.		15/7/28.		31/7/28.	
	Ishan.	Sonko.	Ishan.	Sonko.	Ishan.	Sonko.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
	97.0	105.5	62.5	59.5	92.0	72.0
	42.0	17.0	72.5	49.0	85.0	76.5
	23.0	26.5	15.0	12.0	6.5	9.5
	41.0	41.0	35.5	71.0	31.5	14.5
	43.5	40.0	37.0	25.5	25.5	28.0
	42.0	31.5	35.5	27.0	50.0	18.5
Total yields	288.5	261.5	258.0	244.0	290.5	219.0
Equiv. yield per acre.	192.3	174.4	172.0	162.6	193.6	146.0

(3) Total yield of Ishan plots = 837 lbs. equiv. of 168 lbs. per acre
,, ,, Sonko ,, = 724.5 ,, ,, 161 ,, ,,
(4) Total yield of plots planted 30/6/28 = 550 lbs. = 183.3 lbs. p.a.
,, ,, ,, 15/7/28 = 502 ,, = 167.3 ,,
,, ,, ,, 31/7/28 = 509.5 ,, = 169.8 ,,

SCALE PLAN OF KPEVE COTTON TRIALS (1928-1929).

WITH TREATMENT AND LINT YIELD.

Block A.

		lbs.
40	Edge Plot	90½
39	Flat 4′ × 3′	70
38	Ridged 4′ × 3′	54
37	Flat 4′ × 2′	50
36	Ridged 4′ × 2′	39
35	Flat 4′ × 1′	59
34	Ridged 4′ × 1′	41
33	Flat 4′ × 3′	39½
32	Ridged 4′ × 3′	36½
31	Flat 4′ × 2′	34½
30	Ridged 4′ × 2′	38
29	Flat 4′ × 1′	37½
28	Ridged 4′ × 1′	39
27	Flat 4′ × 3′	41½
26	Ridged 4′ × 3′	44½
25	Flat 4′ × 2′	52
24	Ridged 4′ × 2′	51½
23	Flat 4′ × 1′	42½
22	Ridged 4′ × 1′	52
21	Edge Plot	32

Block B.

		lbs.
20	Edge Plot	64½
19	Flat 4′ × 1′	61½
18	Ridged 4′ × 1′	54½
17	Flat 4′ × 2′	65
16	Ridged 4′ × 2′	77
15	Flat 4′ × 3′	77
14	Ridged 4′ × 3′	54½
13	Flat 4′ × 1′	64½
12	Ridged 4′ × 1′	29½
11	Flat 4′ × 2′	36½
10	Ridged 4′ × 2′	65
9	Flat 4′ × 3′	52
8	Ridged 4′ × 3′	50
7	Flat 4′ × 1′	44½
6	Ridged 4′ × 1′	76
5	Flat 4′ × 2′	64
4	Ridged 4′ × 2′	68
3	Flat 4′ × 3′	46
2	Ridged 4′ × 3′	45
1	Edge Plot	75½

Path.

10 chains

10 ft

Block C.

		lbs.
61	Edge Plot (I.)	61
62	Sonko 30/6/28	41
63	Ishan 30/6/28	41
64	Sonko 15/7/28	71
65	Ishan 15/7/28	35½
66	Sonko 31/7/28	14½
67	Ishan 31/7/28	31½
68	Sonko 30/6/28	40
69	Ishan 30/6/28	43½
70	Sonko 15/7/28	25½
71	Ishan 15/7/28	37
72	Sonko 31/7/28	28
73	Ishan 31/7/28	25½
74	Sonko 30/6/28	31½
75	Ishan 30/6/28	42
76	Sonko 15/7/28	27
77	Ishan 15/7/28	35½
78	Sonko 31/7/28	18½
79	Ishan 31/7/28	50
80	Edge Plot (S.)	23

Block D.

		lbs.
41	Edge Plot /S.)	68
42	Ishan 31/7/28	92
43	Sonko 31/7/28	72
44	Ishan 15/7/28	62½
45	Sonko 15/7/28	59½
46	Ishan 30/6/28	97
47	Sonko 30/6/28	105½
48	Ishan 31/7/28	85
49	Sonko 31/7/28	76½
50	Ishan 15/7/28	72½
51	Sonko 15/7/28	49
52	Ishan 30/6/28	42
53	Sonko 30/6/28	17
54	Ishan 31/7/28	6½
55	Sonko 31/7/28	9½
56	Ishan 15/7/28	15
57	Sonko 15/7/28	12
58	Ishan 30/6/28	23
59	Sonko 30/6/28	26½
60	Edge Plot (I.)	21½

Path.

10 chains

Blocks A and B are entirely Sonko.

Blocks C and D are all 4′ × 2′, and all sown flat.

5 chains

5 chains

PAPER No. XXXVIII.

THE RECENT LOCUST INVASION OF THE NORTHERN TERRITORIES, ASHANTI, TOGOLAND AND TRANS-VOLTA, WITH NOTES ON THE LIFE-HISTORY AND CONTROL OF THE LOCUST.

By W. COOK.

INTRODUCTION.

It is well known that locusts have been one of the earliest recorded pests of man's agriculture. From the remains and records of past civilisations many references to the voracity and destructive power of these insects are known.

The " locust problem " must have arisen as soon as man started to till the land and claim some area from the natural vegetation in which to grow his food crops. The advance of agriculture has increased the importance of this problem, for the turning of uncultivated regions of mixed vegetation into vast areas of one or a few particular crops has enormously increased the resources of food of any insects that feed upon them.

This is particularly so in the case of locusts, as, by their immense numbers and sudden invasions, wholesale destruction of crops follows in a short space of time, and an inevitable famine is the result. Locusts are of most danger in countries which have reached what might be described as a half-way mark in agricultural development—that is, those countries which have considerable areas of cultivated land which border vast tracts of wild, untouched areas. Here the breeding places of locusts are not materially reduced, while their food resources are increased. This applies to most parts of Africa at the present day, and numerous are the records of sudden devastations to large areas of food crops by these insects. Australia, as an example of a continent in an early stage of agricultural development, is just beginning to feel the effects of locust outbreaks.

The other side of the question can be seen in countries like North America and Western Europe, where, owing to the reduction of uncultivated areas to a minimum, breeding-places of locusts have become extinct and the problem is no longer of importance.

PLATE I.

LOCUSTA MIGRATORIA MIGRATORIOIDES, R. and F.
ADULT FEMALE. (PHOTO H. A. DADE)

Locusts have undoubtedly assumed more importance over other insects as pests of man's agriculture, both in past history and, in fact, until quite recently, owing to a complete ignorance of their habits and life-history. Their sudden unexpected appearance in tremendous swarms, their powers of destruction and then their equally sudden disappearance, when no more is seen or heard of them for a number of years, have been a constant mystery, and any methods of control have been last-minute efforts to save those crops which have not yet been touched.

These defensive methods of control, as was natural under the circumstances, were the only ones that could be applied, and Government Departments went to great trouble and expense to devise the most effective means of killing locusts and hoppers and defending crops. These methods must still be carried out in countries subject to locust attack, but in the last few years, with an increase in knowledge of habits of these insects, an offensive method of control has been proposed, which is directed against the breeding grounds of the locusts in non-swarming years, and a scheme is now under consideration by a Locust Committee appointed by the Board of Civil Research of African Colonies subject to locust attack.

NOMENCLATURE AND LIFE-HISTORY.

The locust which has been swarming in the Gold Coast and West Africa generally during the last two years (Plate I) has been identified by the Imperial Bureau of Entomology as *Locusta migratoria migratorioides*, R and F. It is the tropical form of the migratory locust of temperate countries, *Locusta migratoria*, L, which assumes great importance in South Russia. This locust has been very active of late in French West Africa, and a general outbreak is to be expected.

Locusta migratorioides is recorded generally over Equatorial Africa, together with *Schistocerca gregaria*, Forsk, the desert locust, which, however, confines itself to drier regions. Both species are liable to occur swarming in the Northern Territories, although the desert locust (*Schistocerca gregaria*) has not been recorded there yet. Outbreaks of locusts recorded in previous years have been due to the migratory locust, which is the same species which has caused considerable damage recently.

Before proceeding to a report of the activities of this locust in the Northern Territories, Ashanti, and in Togoland during the last few months, it would be as well to give a very brief general account of its life-history as has already been worked out in other countries. It is hoped that exact information concerning its life-history in this country will be available later, as captured specimens are now being reared in the laboratory, but it is expected that it will in no way differ in general details from that already recorded.

The main details of the life-history of the swarming locusts have been known for some time; it is their periodicity, *i.e.*, the reason of their sudden appearance and disappearance, that is only now being elucidated.

Uvarov and other Russian workers have discovered that this migratory locust has definite permanent breeding grounds in well-defined areas. These have been worked out and described as the form that invades Southern Russia, *Locusta migratoria*. In Asia these breeding areas occur among vast beds of reeds (*Phragmites communis*, L.) in large river basins. New channels to the rivers are often formed in the lower reaches, the old ones becoming filled with sand and transformed into smaller lakes, which dry up. The bottom of the dry lake is covered first with reeds, and then later mesophilous grasses develop, which gradually give way to xerophilous forms. These places are most favoured for oviposition by the migratory locust, the vegetation forming an unlimited supply of food, the more open and drier spots being used for oviposition.

These breeding places cannot exactly be described as swamps, although they occur among numerous rivers and lakes, while the most favourable time for oviposition is when these areas are relatively dry and there is a dense vegetation of reeds and grasses interspersed with barer areas in which the eggs are laid.

As regards the tropical regions, the permanent breeding grounds seem to be amongst jungles of bamboo, reeds and tall grass, in more or less open spaces, with relatively dry soil, but there must also be some more open spaces with shorter vegetation for oviposition. The importance of the climatic conditions of these places is only just beginning to be realised, for the peculiar conditions of these areas make them suitable for mass development of the locusts, as the whole complex of vegetation forms a peculiar local "microclimate" which is probably quite different to that of the surrounding country.

Some of these breeding places of the tropical form of this locust are thought to be in Madagascar, Tanganyika and the Cameroons, but very little work has been done on them, and it is extremely probable that many more exist.

At certain periods swarming of locusts takes place from these breeding areas, the adults migrating and flying great distances, often into regions unlike their natural habitat. It is then that surrounding areas, often a considerable distance away, receive "unexpected" invasions, with disastrous consequences to crops. The factors which influence this periodic swarming are, as yet, very little understood, and are one of the most important points to be worked out, but the climatic conditions play a very large part.

These migratory locusts fly from their breeding areas in large warms and cover vast areas of country. Very little food is taken

during the earlier part of the flight, as the insects utilise their greatly expanded fat bodies.

At night they settle on whatever vegetation they happen to be passing over, and if this is a cultivated area of corn or rice considerable damage may be done by nibbling and breaking down of stems and leaves. They may stay for two or three days, resting in one place before moving off, either amongst the bush grasses or in dense clusters on a road or any bare area.

After flying for some days the swarms have a tendency to split up and settle in wide areas; consequently, places may have visits in successive days all from different directions. Towards the end of their flight, which may last over a month, their fat bodies are exhausted, and the locusts then become very voracious, alighting in dense masses and eating all favourable food plants. Mating takes place some time before eggs are laid, during a period when the swarm is stationary, and afterwards flights tend to become more irregular and not so prolonged.

Oviposition takes place at the end of the flight, the swarm remaining in one place for several days, many dying after depositing their eggs. These are laid in clusters glued together in the shape of long curved cylindrical pods, often as long as the abdomen of the insect itself. The female digs a hole in the ground with her ovipositor and, inserting her abdomen into it, deposits her eggs to a depth of 2 or 3 inches, the male often standing by in attendance.

The hole is covered with mucilage, and after the locust has left practically no trace of it remains. If these are laid in the wet season they will hatch in fifteen days to a month, probably in some cases earlier, although eggs laid at the end of the rains, or in favourable places in the dry season, very probably remain over until the next rains.

The hoppers that hatch out are black, with a yellowish medium stripe along the back. After moulting they turn browner in general colouration, and during their later stages they become distinctly reddish. There are five moults before the adult winged stage is reached, the hoppers increasing in size during each successive instar.

Places of oviposition at the end of a swarming flight of locusts are very often in regions totally dissimilar from the permanent breeding areas. Soft damp soil is preferred, and eggs are often deposited in cultivated areas. Other very favourable places are bush areas, where the grass has been burnt during the dry season, thus leaving considerable bare patches of soil, which become soft and damp with the arrival of the rains, the new green growing grass forming a plentiful food supply for the hoppers.

Like the adults, the hoppers swarm in vast armies and migrate during the day. As they have no wings they progress along the

ground by leaps and feed voraciously on any suitable vegetation in their line of march. They settle for the night, clustering on grasses and other plants, and move by daylight. The whole nymphal life varies between thirty-six days and two months, by which time the winged adult stage is reached, the adults flying off again in swarms.

It will be seen from this general description that the hoppers cause by far the greatest damage, and locust control work should concentrate on the wholesale destruction of these swarms immediately they are hatched. Owing to their habit of progressing in dense bands along the ground, they eat everything suitable in their line of march, thus causing far more damage than the adults, which, by the mere fact of flying, may pass over considerable areas of suitable food without landing.

A word may be said here concerning the present theory of "periodicity" that seeks to explain the sudden appearance, and just as sudden dying out, of these swarms after a general outbreak.

This locust has a solitary phase which until quite recently was regarded as a separate species, *Locusta danica*, L. This is widely distributed over the Old World between latitudes 60 N. and 40 S. It differs from the swarming phase only in minor details of colour, and has a much greater variety in size. The details of life-history of this phase are essentially the same as that of the swarming phase, except that under normal circumstances it does not swarm and thus generally attracts no notice.

It has been found that swarms resulting from hoppers, which have come from eggs laid by the heavy swarms at the commencement of an outbreak, are smaller in size and tend to become more scattered. The progeny of these smaller swarms generally do not migrate at all, but scatter and become lost, the whole outbreak dying down. What is happening is that at each successive generation more and more locusts turn into the solitary phase and separate from the main swarm, scatter and are lost. The latter swarms generally always suffer mortality through parasitism and sometimes fungus disease, many also dying through sheer exhaustion.

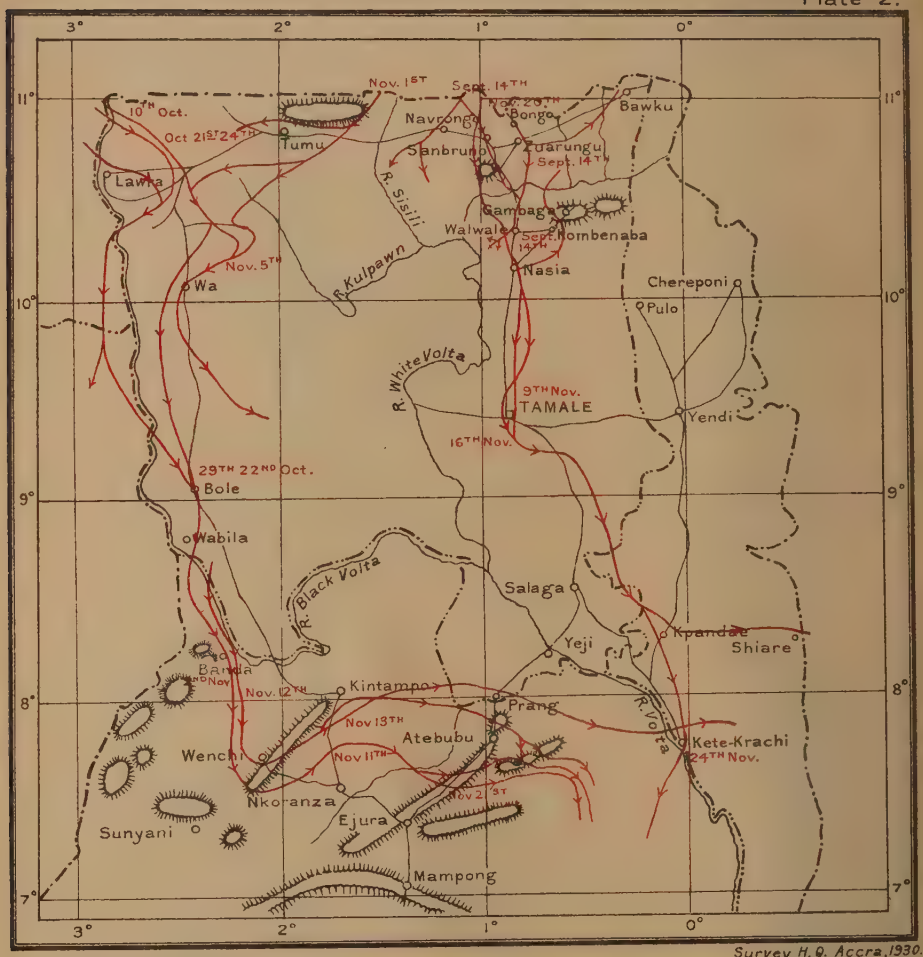
In the permanent breeding areas the reverse process takes place, as there is a gradual changing of locusts from the solitary into the swarming phase over several generations. This process continues until mass swarming from these areas results. The conditions which accentuate this phenomenon are as yet unknown, although it is thought that climatic conditions play an important part.

PREVIOUS OCCURRENCES OF LOCUST INVASIONS IN THIS COUNTRY.

Owing to the very recent development of the Colony, and the still primitive state of the Northern Territories, history of past attacks is somewhat difficult to obtain. It seems certain, however,

NORTHERN TERRITORIES AND ASHANTI.

Plate 2.



Survey H. Q. Accra, 1930.

PATH OF THREE MAIN INVASIONS OF LOCUSTS WITH APPROXIMATE DATES.

that this Colony has suffered invasions before, even on a larger scale than the recent outbreak, and that the same species of locust was responsible.

Old natives in the Northern Territories spoke of a very heavy outbreak during last century, some years before the advent of the white man in those parts. It occurred during a time of heavy tribal warfare, and there followed in its wake a very severe famine.

Another outbreak occurred in the Northern Territories in the nineties of last century. In 1898 heavy swarms were seen in Gambaga, and in 1893 a few flights even visited Accra.

Another heavy invasion of the Northern Territories broke out during the influenza year 1918, and very severe damage was done in the Lawra district. In 1916 flights of locusts were reported in the Wenchi and Kintampo areas, similar to those seen this year.

The Trans-Volta region and Togoland do not seem to have had a bad outbreak since the one record of thirty years ago, which, in all probability, would be the same as that recorded in Gambaga in 1898.

A few chiefs, however, spoke of a few flights in this district in the influenza year of 1918, which seems to show that bad outbreaks in the Northern Territories eventually spread down to Southern Togoland.

The recent invasion started, as far as this country is concerned, in November, 1928, when several large swarms entered from French country from the West, and, flying through the Lawra and Wa districts, disappeared in the uninhabited portion of North-West Western Dagomba. Little damage was done, however, as corn had been harvested at that time.

The older natives of the Northern Territories have a tradition that locusts come fairly periodically for three successive years, and a great many superstitious beliefs are bound up with their arrival.

It was quite common to find old men who had seen invasions about four or five times during their life. Most of the people in Togoland and Trans-Volta, however, had not seen swarms before, but a few of the older men had traditions that they were bringers of evil, owing to the fact that their fetishes were not satisfied with their sacrifices.

REPORT OF THE RECENT INVASION.

(a) Northern Territories and Ashanti.

As early as June and July of 1929 heavy swarms of locusts were reported by natives in the French territory of the Haute Volta region. During the rains at that time this area was subject to a very

heavy invasion, natives reporting that villages were constantly visited by large swarms for many successive days.

Egg-laying areas were recorded by the inhabitants in many towns and villages lying in a line through Mopti, Bandiagara, Ouahigouya, Yako, Ouagadougu and Po, which town is near to the southern border of the Haute Volta, north of Navrongo. The resulting hoppers hatched out when the corn was still young and green, and, migrating in dense bands in all directions, caused very severe damage, so that there is now a serious shortage of food in that region.

It seems highly probable that those adult swarms that invaded this country had their origin in some of these bands of hoppers that were devastating French territory during the early and middle part of last rainy season.

This country was subject to three main invasions from the Haute Volta (*see* Plate II for general direction taken by flights).

1. A large swarm first entered this country between September 14th and 16th, 1929, at Fwegu, in the Zuarungu district. It took a south-easterly direction and passed over Namogo, Samboligu, Bongo to Zuarungu itself, where it divided into two parts. One of these passed eastwards through Nangodi, Sekoti and Detokko, and so into the Bawku district, and the other turned south and flew over Shega and Tiliga to Walwale. Millet and guinea corn was extensively damaged on the way, and eggs were laid at Bongo and Detokko.

At the same time another large swarm entered the Navrongo district from French territory and passed south-eastwards through Sambrungo, where eggs were laid, a second lot going southwards to Sheregu and Winkogo, crossing the White Volta at that point.

2. The swarms that visited the Wenchi and Kintampo areas during the first half of November also had their origin in the Haute Volta. The course taken by these swarms has been fully worked out.

A large swarm entered Lawra from French territory on October 10th, 1929, and proceeded south-eastwards. Two days later they turned westwards, and, having entered the Wa district, crossed the Volta again to French territory, and proceeded southwards along the river towards the direction of Bole.

Between October 21st and 24th the town of Lawra was again visited by three large swarms, all from French territory. These proceeded south-eastwards, causing extensive damage to corn in their line of flight, and entered the Wa district at Bussie (October 27th), flying on to Issa and Kudjoperi.

A large swarm, which again entered from French territory at Wuru in the Tumu district (November 1st approx.), passed to the

south of Tumu itself, and, touching the southern area of the Lawra division, augmented the swarms already circling in the Wa district. One of these passed over Wa (November 5th) and proceeded towards Bole, afterwards turning south-east.

Bole was visited by two of these swarms (October 22nd and 29th), these doing extensive damage to the farms in the district, as the corn was about ripe and had not been harvested. After leaving Bole a smaller body branched off from the main swarm and proceeded south-eastwards. The main body, however, moved off southwards and, passing through Wabila and Ntereso, crossed the Volta at Dobbo, and entered the uninhabited north-west corner of the Kintampo district.

They were next heard of in the Banda division (November 2nd and 3rd), and, crossing the River Tain, reached N'kunsia some five miles south of Wenchi (November 5th). Here they veered eastwards, having reached the forest area, and, doing extensive damage on the way, crossed the Kintampo-N'koranza road some 18 miles to the south of Kintampo (November 11th).

On November 12th another of these swarms came from the same direction, passed over the Banda division and, veering round at the south of Wenchi, proceeded north-eastwards, crossing the Kintampo N'koranza road three miles south of Kintampo. These two swarms proceeded eastwards, the former flying slightly to the south, crossed the Ejura-Yeji road by the villages of Affrafreso and Abuo, and turned into the Kumawu and Kwahu districts towards Berem, after which no further trace of them was recorded. The latter swarm proceeded eastwards through the Abeasi district, where extensive damage was done, and, crossing the Ejura-Yeji road just north of Atebubu, turned southwards, and was lost, like the former flight, in the Kwahu district around Berem.

The Ejura-Yeji road was crossed by several smaller swarms in the succeeding days (November 13th to 20th), whose general direction was west to east. These had undoubtedly branched away from the two primary swarms when passing through the Abeasi and N'koranza districts. Some of these turned southward to the Berem district and the Afram plains, while one proceeded due eastwards towards Krachi, passing just north of that town (December 1st), having first taken a more northerly route *viâ* Prang.

3. About October 20th, 1929, a large swarm entered from French territory to the east of Navrongo, and, proceeding southwards, crossed the White Volta at Na in the Navrongo district, where they stayed for one night. Continuing their course, they spent the next night at Du, and, passing over Zangum and Zangu, reached Wungu the following evening.

Very severe damage was done in this district, as there is extensive corn cultivation around the villages themselves. The swarm

then proceeded southwards to Nasia, where a small portion branched away and flew north-eastwards to Paragu and Kombenaba, in the Gambaga district. These crossed the White Volta again to the north-western uninhabited portion of Western Dagoma. The second entered the Lawra district somewhere to the east of Tumu, and, taking a westerly course, passed Navere, and flying by the south of Tumu itself and through Dasima, reached Jiripa, some 26 miles to the south-east of Lawra. It circled there for some days before proceeding eastwards again to the Wa district. Swarms were circling about this region for some time, as Nakwabi (Western Gonja) on the Wa-Bole road was visited (November 23rd) by a swarm coming from the east which passed into French territory. Bole received a further flight from the north-east (December 25th), this again crossing the Black Volta into French territory.

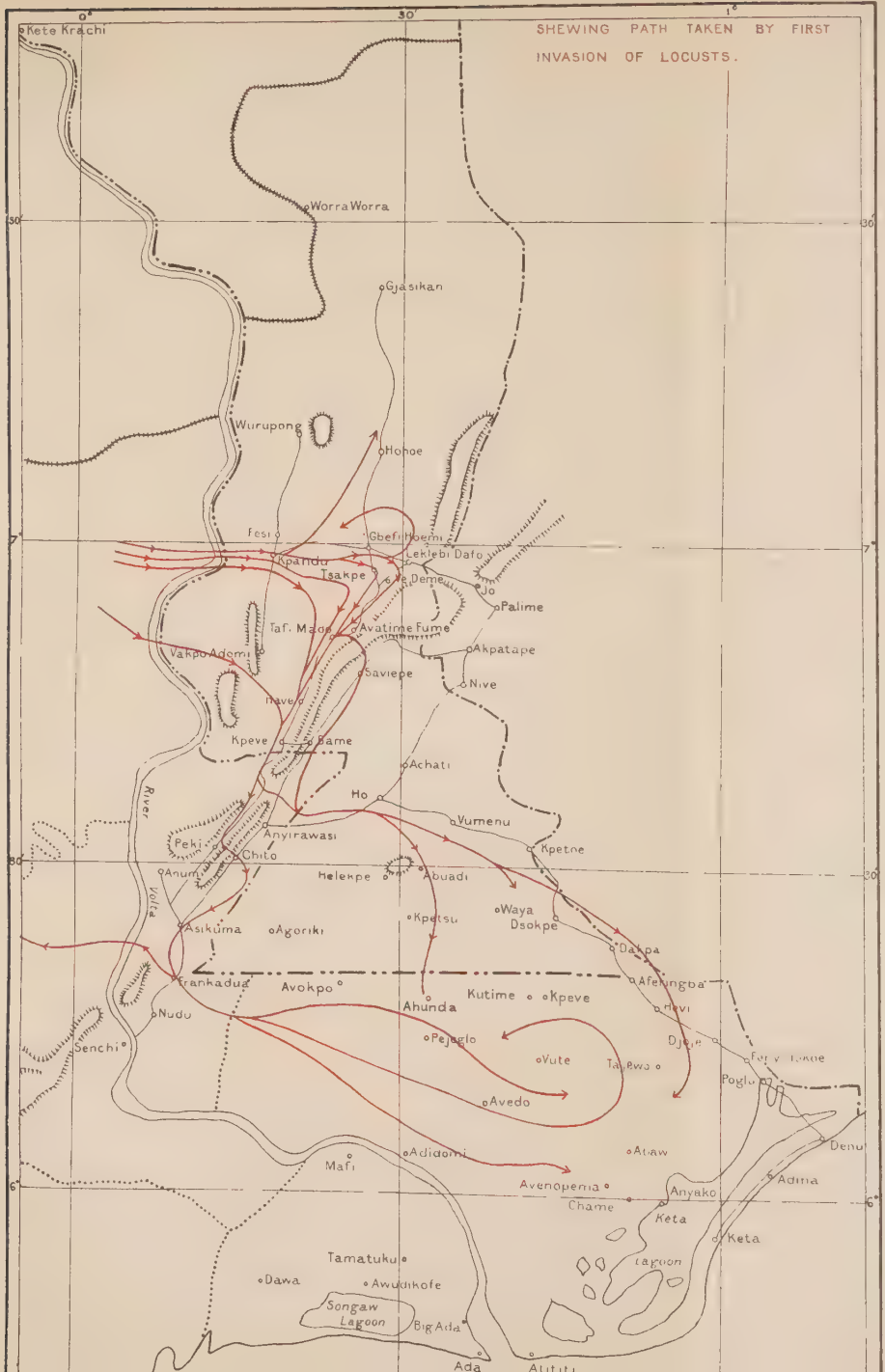
Later the Wenchi area was again invaded from French territory to the west by several smaller flights. These entered at Sikasiko on the western border (December 22nd), and, proceeding southwards, passed by Drobo. Like the former swarms, they turned eastwards and northwards on reaching the forest area. Passing by the north of Wenchi, they continued their eastward course, and did some damage to late corn in several villages some 12 miles north of N'koranza, a portion of them crossing the Ejura-Yeji road by the villages of Yoribon and Kassay-Zongo (January 1st, 1930, approx.). They crossed the road again at Affrafreso and Akokua, this time circling round to the west, but later turned northwards and passed over Atebubu (January 6th). Flying towards Salaga, they turned south again (January 10th) and, passing over Yeji (January 13th), were last heard of on the Krachi-Atebubu road.

A very full report, kindly sent in on January 20th to this Department by Mr. K. R. Stacey-Morris, Assistant Entomologist, Medical Department, who is stationed in the Northern Territories, stated that small swarms were still general along the Nasia River close to Suguri and Namburugu, and also around the Gambaga-Tamale road. These, however, were having a tendency to scatter, and many isolated individuals were observed.

(b) Southern Togoland and Trans-Volta.

The invasion of the southern part of Togoland and the Trans-Volta region did not take place until considerably later than that of the Northern Territories. They appear to have entered Southern Togoland about the beginning of December, although there was one record of them having been seen at Kpedze on November 26th.

Three large swarms came from the Afram plains, crossed the river and, passing over Kpandu, turned southwards (*see* map


SHEWING PATH TAKEN BY FIRST INVASION OF LOCUSTS.
Kete Krachi
Worra Worra
Gjasikan
Wurupong
Hohoe
Fesi
Gbefi
Hoemi
Leklebi
Dafo
Kpando
Tsakpe
Deme
Jo
Palime
Taf. Mado
Avatime
Fume
Vakpo
Adomi
Akpatape
Saviepe
Nive
Have
Kpeve
Bame
Achati
Ho
River
Vumenu
Anyirawasi
Pehi
Chito
Kpetne
Anum
Helekpe
Abuadi
Volta
Waya
Dsokpe
Kpetsu
Asikuma
Agoriki
Dakpa
Frankadua
Avokpo
Afelungba
Kutime
Kpeve
Ahunda
Nudu
Pejeglo
Senchi
Vute
Avedo
Poglo
Adidomi
Ataw
Mafi
Denu
Avenopemia
Adima
Anyako
Chame
Keta
Keta
Tamatuku
Lagoon
Dawa
Awudikofe
Songaw Lagoon
Big Ada
Ada
Alutu

(Plate III) for general direction). Another crossed the river at Vakpo, some 14 miles to the south of Kpandu, and flew in a south-easterly direction. The general direction taken by these swarms was down the valleys in between the main Togoland range, which crosses the country from Anum to the north of Palime along a line pointing N.E. to S.W.

First flying through the Ve district, most of them proceeded down the Bame-Pechi valley and, arriving at Chibo, crossed over a gap in the hills to Chito, a small branch passing off to Anyirawasi and Ho direction, flying from there southwards (December 16th). The other division flew south-westerly, along the range of hills, over Asikuma to Frankadua, where they divided, the main portion turning south-eastwards over Podi and Agodeka to the Abor district (December 15th) in the Keta division, and the other passing over to the Krobo district across the Volta, through Agina and Odorno, eventually passing 15 miles to the north of Bisa (December 10th approx.).

The swarms in the Abor and Kpedsu districts circled about this area for some time, doing extensive damage to farms, especially in the highly cultivated areas around Abor. Villages along the Ho-Denu road were visited, many of them several times.

These swarms had a tendency to split as several smaller flights proceeded northwards, and crossing over gaps, and in some cases over the hills themselves to the North of Ho, flew up the Kpeve and Bame valleys, and re-attacked the Ve and Dafo districts.

These flights were generally taking a very erratic course and seemed to be split up by the ranges of hills. One swarm, flying westwards down the valley at Hornutu, was actually observed to divide; one portion traversed the range of hills to the southward towards Nive, and the other continued over the hills to the North, reaching Dafo the following morning.

All the swarms in the Trans-Volta district came from the Afram plains, after first crossing the Volta at Kpandu; the later flights up the valleys from the Abor-Kpedsu district to the South were due to divisions of the primary swarms.

It is possible that some of those swarms, which first visited this region, may have been remains of the Northern Territory swarms recorded above, which became lost in the Afram plains and the Kwahu district. On the other hand, many of the swarms examined in Togoland were still comparatively young adults, which tends to the view that they originally bred out in the Afram plains independently of the Northern Territory flights.

It is unlikely that they were the progeny of the original Northern Territory swarms, for, had these laid eggs, they would not have had time to hatch and become adult again by the beginning of December, when the first swarms invading the Kpandu region were recorded.

No record of this independent breeding has, as yet, come to hand, but the region of Afram plains contains many areas suitable to the breeding of this locust, and further, as it is very sparsely inhabited, records would be difficult to obtain.

REMARKS ON NATURE OF DAMAGE, AND OBSERVATIONS MADE DURING INVESTIGATIONS.

Locusta migratoria migratorioides generally confines itself in its feeding habits to the order *Gramineæ*. When starved, or when in want of water, of which it requires a considerable amount when in flight, it has been known to attack other plants, such as palms, plantains and other shrubs, but it will only eat these in extreme cases.

Curiously enough, in the Trans-Volta region this year, where the country was exceedingly dry after an exceptionally long dry season, it was not uncommon to see coconut palms, and, in several cases, oil palms, the leaves of which had been defoliated by the locusts in passing. With the above exception, the damage done was, in most cases, to guinea corn, maize, millet and rice, but small patches of sugar-cane, grown about villages, were also destroyed, as were all the bush grasses, particularly the elephant grass (*Pennesetum purpureum*) of Northern Ashanti and Togoland.

Damage in Ashanti was relatively light compared to that in the Northern Territories or Trans-Volta, many extensive food-growing areas, which were out of the path of the swarms, escaping completely. Damage to farms was universal in the Northern Territories, practically every village having several visits, the Bawku district escaping the most lightly. The very extensive corn cultivation around the thickly-populated areas of Zuarungu, Navrongo, Lawra and, to a certain extent, Wa suffered severely, many farms having been completely ruined, so that no trouble was taken to harvest the remnants.

A rough idea of the damage done can be given by the following table, the information having been obtained through the courtesy of the various District Commissioners concerned :—

District.	No. of Farms destroyed.
Krachi	10,000–15,000 small Dawa farms 3,300–5,000 Rice farms.
Zuarungu	238
Gambaga	585
Wa	1,739 (331 undamaged)
Bawku	296
Lawra-Tumu ..	2,491
Navrongo	2,343

This estimate of damage, of necessity a very rough one, was made at the beginning of December, and it is extremely likely that much more damage was done than that indicated above.

Damage to corn was caused by the locusts stripping off all the leaves, so that only the bare stems and the ribs remained. They fed indiscriminately on both the cultivated graminaceous crops and the wild grasses in the surrounding bush areas. Quite commonly the ends of the young maize cobs were nibbled, but these were generally left hanging from the bare stem. In Western and Northern Ashanti, and also in the Krachi districts, many rice farms were destroyed, the seeds particularly being eaten.

The first swarms that invaded the Northern Territories arrived when the corn was still green, and there was some hope of it recovering owing to the further rains. Later invasions, however, soon put an end to this, and a great portion of the guinea corn and millet was destroyed long before it was due for harvesting. Still later swarms did little damage, as all corn left by the previous flights had been harvested. The second crop of maize in Ashanti, around the Kintampo and Wenchi areas, was still green when visited by these smaller later swarms, and quite considerable damage was done wherever the locusts landed.

In Southern Togoland and the Trans-Volta the chief damage was done to maize, although scattered rice farms were destroyed around the Kpandu area. The extensively cultivated region around Abor north of the lagoon, as well as numerous farms along the Ho-Denu road, suffered severely, practically all the maize having been destroyed by the earlier flights. Farms that escaped from these swarms were destroyed by later ones, and the only untouched farms

observed were in a small area around Tajewo to the west of Djoje. Scattered farms have been damaged in the Ada district across the Volta, owing to some of the swarms circling over the river. The great majority of farms in the infested areas, especially those in the Northern Territories, have no corn for planting next season. Other food crops commonly grown, such as yams, cassava and groundnuts, were untouched. Very little cassava is grown in the Northern Territories, and their only alternative food crop is the yam and a small amount of groundnuts.

So far, except for three places in the Zuarungu district (Sambrungu, Bongo and Detokko), damage has been entirely due to the adult locust. Eggs were laid in cornfields at these villages by locusts causing the first invasion (September 14th, 1929). The ground was still soft and damp and the corn was green and between 5 to 6 feet high. The egg-laying areas of the former two villages were about half of a square mile in extent, while that of the third was in a very small area of corn, amongst an outcrop of rocks.

The hoppers hatched out nine to fifteen days afterwards and commenced damaging the still growing corn around. They moved about indiscriminately in thick clusters around the egg-laying area, and in the first two villages concerned holes were dug and many of them were driven in and killed, the whole population turning out to help in their destruction. No steps were taken against the hoppers at Detokko. There the egg-laying area was very small in size—in fact, only a portion of one man's farm—and the hoppers were allowed to move off.

No other egg-laying area was found either in the Northern Territories or in the Trans-Volta region up to the end of this primary investigation, although several reported ones were examined without positive results. All places in the Gambaga, Zuarungu, Navrongo, Lawra-Tumu, Wa and Bole districts, where locusts were reported to have stayed for over two days, were examined, and no trace of egg-laying was found. This was also the case in Togoland and the Trans-Volta district. Here several egg-laying places were actually reported, but an examination of these areas showed that no oviposition had taken place.

The reason for this is due to the fact that the greater majority of swarms come when the dry season is well established, and as these were comparatively recent adults they were not ready to lay eggs. Many specimens captured from swarms were dissected and no trace of developing eggs were found in the females; the ovaries were in the same undeveloped stage as is usual for the recently emerged imago. The eggs laid during the swarming phase of this locust remain in this rudimentary state for some time, and only commence to develop rapidly towards the end of adult life. The adults may remain alive for over sixty to seventy days, and when sexual maturity is reached, the insects then assuming a yellowish colour, the process

of egg-laying takes place. This is automatic and occurs wherever the insect happens to be, and if this is an unsuitable spot many of the eggs die, so that, consequently, no hoppers appear.

From native information gathered during this investigation some interesting facts regarding oviposition were brought to light which will help to make clear the position at the present time.

Older inhabitants of many villages visited in the Northern Territories had had experience of swarms of locusts in their young days. Those villages that observed egg-laying taking place in their districts, and the subsequent infestation of hoppers, all recorded that the egg-laying swarms came during the latter part of the wet season, when the corn was still green and about 5 to 6 feet high. These laid their eggs in damp places, in between the grasses in the bush, or in cultivated fields. The bare soil in between the wide planted corn would serve as an ideal place. No eggs were laid in swamps themselves or amongst the characteristic swamp grass.

Hatching took place generally from twelve to twenty days after, this in many cases coinciding with the break of the rains. In those cases where hoppers hatched out on farms extensive damage was done to the corn, the hoppers moving off during the first few weeks of the dry season. A shortage of food inevitably followed.

This information agrees with those observations made this season at the three egg-laying areas in the Zuarungu district.

Several cases were recorded around Lawra in which locusts arrived just at the end of the dry season. These oviposited in a damp area in the bush around a stream, and hoppers came out just after the corn had been planted, completely spoiling the crop, as it was only a few inches high.

The great majority of past records show that oviposition by locusts in the Northern Territories was of the former type—that is, egg-laying took place during the rains, the hoppers hatching about a fortnight to three weeks later. This apparently has been the case in the Haute Volta during last rainy season, and it is the later flights of adults from that region that have invaded this country. All natives in the Northern Territories, who have had previous experience of locusts, were unanimous in saying that those that came this year were much later than those of former invasions.

In Togoland and Trans-Volta the position is different. Information obtained concerning the previous heavy invasion there twenty-five years ago showed that the adult flights then occurred about the same time as those this year—that is, during the latter half of the dry season.

Eggs were laid in many places where the grass had been burnt. This burning of the bush grass takes place in January, whereas the Northern Territory people begin to burn their bush in November.

Oviposition took place just at the commencement of the rains, chiefly in these burnt areas.

The soil in these areas would be very soft and bare, with scattered blades of young green grass springing up. When moistened by the first rains, these areas would form ideal egg-laying places, and as a great proportion of the country is laid bare by these bush fires, swarms of locusts finishing their flight would have little difficulty in locating such places.

Hoppers hatched out in dense bands all over the country and did very great damage to young corn, which in most places had only just germinated. Other records showed that corn between 2 and 3 feet high was also destroyed by swarms that hatched later.

From native records there was a serious shortage of food that year among the inhabitants of the affected areas, and they have fears of a similar shortage this year. In the previous invasion the damage done by the adults was negligible to that caused by the resulting hoppers.

Here, again, natives who have had previous experience agreed that conditions during December and January this season were too dry for successful egg-laying unless some suitable spot was found.

THE PRESENT POSITION OF THE AFFECTED AREAS IN RELATION TO HOPPER OUTBREAK.

The position in the country up to the present time (January, 1930) can be summarised as follows :—

(a) Northern Territories and Western and Northern Ashanti.

Except for the three villages mentioned above in the Zuarungu district, where eggs were laid by a swarm coming at the end of the wet season, no oviposition has been recorded.

The large swarms causing the second main invasion that entered the Lawra and Wa districts, and finally passed through Western and Northern Ashanti, did not oviposit in these areas. They were eventually lost sight of in the Kwahu and Afram districts, where oviposition has in all probability taken place, as they would then be reaching the end of their flight.

The large swarms that entered this country at Navrongo and caused the third main invasion passed over Tamale flying southwards. These did not oviposit anywhere along this route. Some of them, however, passed over Krachi and entered the Afram plains, where, like their predecessors, further trace of them was lost. It is not unlikely that oviposition has taken place there, although there is no record of it as yet.

Smaller swarms, branching off from these main flights, were flying over the Northern Territories during the latter half of November and during December, two smaller flights entering from the Haute Volta at this time.

The erratic courses taken by these swarms were influenced not only by the *harmattan*, but also by the extensive bush fires which by that time had laid bare practically the whole bush areas. These later swarms had a strong tendency to split up; in all probability the dense layers of smoke from burning bush all over the country had a great bearing on that phenomenon.

Several times during the latter half of December and the beginning of January small flights of not more than 200 or so locusts were observed. These would be flying very erratically, and were generally travelling in the same direction as the *harmattan*.

The extensive bush burning, and the very dry conditions of the country during that time, make the chances of a swarm alighting on a suitable place for oviposition very remote. It is highly probable that a large proportion of these small flights eventually perished without any successful egg laying, as, apart from the unfavourable conditions, suitable food plants would be rare.

The fact that the swarms were becoming thinner would lessen the danger of large bands of hoppers hatching out.

Up to the time of writing small flights are traversing the district around Yeji and the Volta, as well as in the Gambaga and Zuarungu districts, and as these will reach sexual maturity about the time of the first rains there is some danger of these ovipositing successfully, for the burnt bush will then present many favourable areas.

It may be said here that traces of some swarms were lost in the large uninhabited area in the north-west corner of Western Dagomba, which lies to the north of the White Volta at Lungbungu and Singa. Consequently, egg-laying may have taken place there without any record. It is interesting to note that the swarms which caused the October-November, 1928, invasion of the Lawra and Wa districts entered this area, and nothing more was heard of them.

It is unlikely that the affected parts of the Northern Territories and Ashanti will be subject to large swarms of hoppers during the coming rainy season. There is some danger, however, of scattered bands appearing, which would arise from the later small flights that eventually find suitable egg-laying places.

A possible danger, too, which is by no means unlikely, is a further invasion of adult locusts from French territory as soon as the rains set in, as swarms may have oviposited just over the border in suitable areas during the dry season. These would hatch out on

the arrival of the rains. If any swarms should enter the country at such a time energetic measures will have to be taken to discover where they eventually breed, otherwise the resulting hoppers will do serious damage to the growing corn.

The hope that the bush fires would destroy eggs was expressed by some officials in the Northern Territories. It is certain that a strong bush fire would destroy a certain percentage of egg-clusters if passing over an area where locusts have oviposited. But as the swarms during November and December (*i.e.*, when bush fires were at a maximum) had not reached sexual maturity, it is unlikely that any eggs were laid at that time.

(b) Togoland and Trans-Volta.

The invasions of these areas did not take place until some considerable time after that of the Northern Territories.

The swarms originally entered from the Afram plains and, turning southwards at Kpandu, proceeded down the valleys of the Togoland range and entered the Kpedsu and Abor districts to the north of the lagoon.

Smaller flights branched away from these main swarms and, taking a general northward direction, proceeded over the hills and again infested the Ve and Dafo districts.

Up to the time of writing swarms are still circling about the Dafo, Ve and Kpeve districts, but these are becoming divided and more scattered. This is due to the many hills in this region, which have belts of semi-forest and cacao on their southern sides, alternating with open bush on their northern slopes. Small flights of locusts, a few score yards in length, were commonly observed flying over the tops of the hills and along the valleys, these being split off from the larger swarms that had previously travelled through the valleys. The courses taken by these swarms now in the hilly region are very erratic, and there is no definite line of flight.

Several fair-size swarms are still circling the Keta-Ada district, where the country is very flat and somewhat extensively cultivated. They have not reached sexual maturity, and they do not show as much tendency to scatter as those flying among the hilly districts.

At the time of leaving this area (January 28th) extensive bush burning was going on, particularly around Kpedsu, Abuadi and Dsokpe. These fires will probably make the swarms tend to break up, as these areas, already very dry, would thus be leaving very little suitable grass on which the locusts could feed.

As in the Northern Territories, these burnt areas will serve as ideal egg-laying places when moistened by the first rains, which are now due, and there is every likelihood of some of these swarms ovipositing at that time

Although the position is not so serious as that of twenty-five years ago, when hoppers hatched out practically all over the country during the early rains, there is fairly certain to be a few bands of hoppers hatching from eggs laid by the swarms still in the country.

Steps should be taken to exterminate these as soon as possible after hatching, for hoppers invading the rich food areas to the North of the lagoon, and again around Kpandu, would do very serious damage.

No egg-laying has been observed up to the time of leaving these areas, but conditions were then very dry and unfavourable and the swarms still there had not then reached sexual maturity.

There is also to be considered the possibility of a fresh invasion of a few swarms of adult locusts from the Afram plains during the next rainy season. As explained above, several large flights became lost in that region last December, and the probability of breeding taking place there cannot be overlooked, as it comprises an area eminently suitable for that purpose.

PREVENTIVE MEASURES USED AGAINST LOCUSTS OBSERVED DURING THIS INVESTIGATION, WITH AN ACCOUNT OF METHODS OF CONTROL APPLICABLE TO THIS COUNTRY FOR THE PRESENT CAMPAIGN.

During the recent heavy locust invasion, in which damage was done by adults alighting on crops when in flight, it was only in exceptional cases that any steps were taken by natives to save their farms.

A few instances were observed in Trans-Volta, where farmers and all their families walked up and down in line through their corn, waving their arms and making noises by beating on drums and petrol tins. This, when continually kept up, prevented the locusts alighting in great numbers, as they are very easily disturbed. The great majority of a swarm in flight do not land, but only a comparative few of the lower flying ones, which tend to fly irregularly as compared with those higher up. Those which alight, however, which are few in comparison with the numbers that continue flying, are of sufficient numbers to destroy entirely a native farm if left untouched. They are, however, comparatively easy to disturb, and when this is done they rejoin the main line of flight, after describing a few irregular circles.

That these energetic measures, which were taken by a few natives, were not wasted was seen from the fact that their farms were conspicuous amongst those of their neighbours, which were completely destroyed. The measure, purely defensive in saving

crops, is, however, to be recommended. Many of the farms owned by natives are small, and damage to these by passing flights of locusts could be minimised by getting the owners and their families to disturb the alighting insects, by starting bonfires wherever possible, beating through their corn, and making every possible noise.

As far as locust control itself goes this method is, of course, of no value, as it merely succeeds in driving on the swarm to the next man's farm. It is, however, a commendable method for saving crops from complete destruction, and when employed has a fair measure of success against the smaller flights. On the other hand, the moral effect on a native farmer, when, despite his efforts, swarms continually visit him, must not be overlooked.

Defensive methods used in locust control work should be concentrated on the destruction of hoppers. Very little can be done to destroy the adult flights. Methods of destroying these have been employed in other countries. These have mostly taken the form of sprays used against swarms when they have alighted for the night, and are not at all practicable for use in this country.

The most primitive method used for the destruction of hoppers is the trench method. This has been used from time immemorial in all locust-infested areas, but has now, apart from the very backward and primitive countries, given place completely to more effective, cheaper and scientific methods.

The trench method merely consists of digging trenches, with vertical sides, in the line of march of a swarm of hoppers, and either driving them in or letting them enter of their own accord, afterwards burying the entire mass in the trench.

This method was adopted this season by natives in the French territory against the many bands of hoppers in the Haute Volta during last rainy season.

In the villages of Bongo and Sambrungo, in the Zuarungu district, where, as recorded above, hoppers hatched out during the end of September, holes were dug by the inhabitants and the hoppers were driven in and buried.

When these villages were visited during this investigation the egg-laying places were examined. Scattered holes, about 12 feet long and 2½ feet deep, by 3 to 4 feet wide, had been dug at random in the area, and the whole population turned out to drive the hoppers. The natives admitted afterwards that many escaped, and only a portion of the swarm was eventually killed. This was undoubtedly due to the fact that these methods were not properly carried out. The holes dug at random would be useless for receiving thick bands of hoppers, and the fact of several hundreds of excited natives trying to divert these clusters of hoppers into the holes would minimise the chances of total extermination, which is essen-

tially what should be performed. Many hoppers would scatter and break through the line of beaters, others would hide under stones, and still others escape between the holes. Some would be buried, and the remainder would be dispersed, only to re-form again a few days later.

Many villages, whose older inhabitants had had previous experience of swarms of locusts, said that it was their custom to dig holes and bury as many of the hoppers as possible. On the other hand, natives of other districts, who had seen swarms and hoppers before, took no steps at all to destroy them and had no idea that any methods could be used. Others reported that it was their custom to light fires at intervals and drive the hoppers into them, while still others used to collect brushwood and dry grass and try to burn a band of hoppers that had settled for the night.

The trenching method, however, can be made comparatively effective when one is dealing with small bands of hoppers. For the best results, if native labour is used, the work must be properly supervised by a qualified individual, who should organise the proceedings as best to suit the local conditions.

A definite trench, at least 3 feet wide and deep, must be dug, with vertical sides. This should be V-shaped and dug in the line of march of the hoppers. Scattered holes dug at random are useless, as it allows too many to escape. These trenches should be dug in the evening and as close as possible to the swarm of hoppers that have settled for the night. Its direction of march during the day must be observed, so that the trench can be dug accordingly. The hoppers generally assume the same direction that they have been taking the previous day, so wherever possible they should be allowed to continue on towards the trench without driving.

Hoppers that have recently hatched generally move about indiscriminately in clusters around their egg-laying area, and do not take a definite line of march. In this case, if the area is small, it would be better to surround them completely with the trench, as it is almost impossible to drive them in any definite direction before they have assumed their migration.

This trench method, although unsatisfactory in better developed countries which have facilities for applying more modern methods, is still practicable in primitive countries where labour can be forced or is very cheap and plentiful. It is essential, however, that it should be properly supervised and carried out.

A modification of the trench method, which gives better results, is the erection of barriers in the line of march of migrating hoppers. These take the form of fences of corrugated iron, or sheets of strong canvas, placed closely together, either at right angles to the oncoming band, or preferably V- or W-shaped, with the arms stretching out towards the direction of march. Pits are dug at intervals

along the barriers, into which the hoppers eventually fall and are buried. Fences can be made of any local material, such as of brushwood or palm leaves, if any are available.

This method depends for its success on the correct observations of the movement of the coming band. Its rate of travelling should be ascertained, so that the barrier can be erected as near as possible to the place where the hoppers will rest for the night. This method is of great value in bare open country where labour is cheap, but is not profitable to use in areas of thick bush. If transport is difficult, and there are no local materials from which the fences can be made, the cost of using this method would be prohibitive.

It is unnecessary here to give in detail the methods of control used in the more developed countries subject to locust invasions, as these would be impracticable in a country such as this.

Methods are becoming more and more refined, and the older unsatisfactory mechanical customs of trenching, burning and erecting barriers have now given place to chemical technique. At the present time the poison bait method is the most satisfactory, and is now giving place to spraying. This consists of mixing a poison (preferably Sodium Arsenite) with a carrier such as bran or sawdust, or dried animal droppings in a suitable proportion, and distributing this in a fine layer over the ground in the paths of moving hoppers. The hoppers are attracted to these mixtures and, feeding on them, are poisoned. The control work should be carried out by a comparatively small efficient staff, so that all the egg-laying areas can be mapped out before hatching takes place. The amount of poison required can then be calculated without having any immense quantities left over, and the hoppers are destroyed as soon as possible after they have hatched.

In this type of control work a trained staff takes in hand the whole campaign right from the beginning of the first invasion of adults. Swarms are followed up, and the places of oviposition found, so that their areas can be cultivated. Meanwhile preparations for the poisoning of the coming hoppers are made at headquarters. The staff are all in their required places a fortnight before the hoppers are due to hatch, and the baits are laid down a few days after hatching takes place.

This method has the advantage of obtaining the complete extermination of every band of hoppers if properly organised, and besides, is the least costly of all the better methods. It requires practically no unskilled labour and is entirely in the hands of a qualified staff. Locust-control work by poison baits has reached a fine art in Southern Russia and Siberia under highly skilled organisations.

As stated above, it is extremely unlikely that this country will be subject to heavy swarms of hoppers during the coming wet

season, but it will be necessary to deal with these swarms that might arise from flights of locusts still in the affected areas.

These, as they will in all probability be comparatively few in number, can be most economically destroyed by the trench method, as labour is plentiful and can easily be obtained in the areas concerned. It is of importance, however, that it should be properly supervised and carried out, as the native methods themselves are very unsatisfactory.

The present state of the locust problem in this country does not warrant the introduction of more scientific methods, which would be more expensive to apply under the conditions of this Colony. If, however, this country should experience further heavy invasions of adult swarms during the coming rainy season, the consequences will be serious, and it would then be advisable for preparation to be made of more up-to-date methods. Of these, the poison method would be the cheapest and most efficient, but it would have to be carried out by trained individuals.

A word may be said, in conclusion, on the present schemes of the Locust Research Committee, which has been appointed by the Board of Civil Research.

This advocates the pursuit of a far-sighted policy in locust-control work, particularly the discovery and detailed study of the conditions of their permanent breeding places, about which very little still is known. The gradual eradication of some of these areas of the migratory locust in Eastern and Southern Europe, especially those formerly around the basin of the Danube, caused by the change in their natural conditions owing to the development of the country, has rendered them now obsolete. The decline in the invasion of locusts in those districts has been very noticeable the last 100 or so years, and the swarming phase now never visits its extinct areas.

It will be difficult to alter the conditions in breeding areas in the tropics, but they can at least be kept under observations. The preliminary increase in numbers of the locusts that usually takes place in these areas before the mass swarming to other regions, could then be observed, and surrounding rich agricultural areas could be warned so that adequate preparations could be made to prevent a general outbreak.

Appendix.

Information has just been received that *Locusta migratoria migratorioides* invaded South-Western Nigeria during the latter part of November and during December. This seems to show that there is a general outbreak all over West Africa, which in all probability reached its climax this season.

Note.

Several locusts captured alive in Togoland from a swarm died suddenly in cages the following day. Fungus mycelium was found ramifying in the thoracic tissues between the sclerites, which have been identified by the Mycological Department as a species of *Aspergillus*, probably *A. ochraceus*, Wilhelm. This fungus is recorded as pathological to insects, and must have been present in the field in the locusts concerned before they were caged. Other dead locusts observed in the field had no fungus on them, but a few more kept in cages have since died of it.

Acknowledgments.

A great deal of the information given above concerning the direction and flights of the earlier swarms was obtained through the Political Department of the Northern Territories. I have to thank the various District Commissioners for very great help and assistance in every way. Thanks are also due to Mr. K. R. Stacey-Morris, Assistant Entomologist, Medical Department, and to Mr. T. Hunter, of this Department, for very full and detailed reports concerning locust swarms that they had investigated themselves. The brief outline of the poison bait method scheme for locust control has been abstracted from Uvarov, in his recent book "Locusts and Grasshoppers."

PAPER No. XXXIX.

POISONED BAITS AS A MEANS OF COMBATING LOCUST INVASIONS.

By W. COOK.

The use of poisoned baits as a method for the destruction of hoppers in anti-locust campaigns has increased greatly during the last few years. Until comparatively recently the standard chemical method employed was that of spraying with an arsenical solution, but in moist countries subjected to periodic locust invasions this method has now been superseded by the use of baits containing an arsenical poison.

The poisoned bait method is based on the positive chemotropism of members of the family Acrididæ (grasshoppers and locusts) towards various substances, in certain states, that are more attractive to them than their normal food plants. The most suitable of these substances are poisoned and then offered to the insects in the field, which feed on these baits in preference to their normal food, and are thus killed.

A bait consists of three parts, carrier, poison and attractant.

CARRIER.

Grasses or various food plants of the locusts, chopped up into small pieces, were first used as carriers, but further experimental work, chiefly on solitary grasshoppers, by American and Russian entomologists has brought to light other substances more convenient and effective than the use of vegetation. From direct observations that many species of grasshoppers tend to collect in numbers upon horse-droppings in the field, dried horse manure mixed with poison has been used very extensively and successfully as a bait. Other substances generally used as carriers are bran, sawdust, broken wheat grains, rice bran and chaff, meal of cottonseed cake, and various local agricultural products of a similar nature, which may be readily accessible in tropical countries conducting an anti-locust campaign.

Bran is the best known, and is the standard carrier used wherever it is easily and cheaply procurable, although for economical

reasons it is often mixed with sawdust with just as effective results. Apart from its attractiveness to the insect, a most important point about a carrier must be its cheapness. Local products of a suitable nature, which may be cheaply and readily procurable, must be tried, and used if successful, where the cost of importation prohibits the use of bran, for the whole anti-locust campaign must be conducted with the minimum amount of cost.

POISON.

The standard poison used in the preparation of poisoned baits is an arsenic compound, but recent experiments have been conducted by various entomologists to test the effectiveness of sodium fluoride and fluosilicate, and compare their efficiency with the most widely used arsenical salts. Uvarov, in his book "Locusts and Grasshoppers," quotes the standard poison baits as sodium arsenite $\frac{1}{4}$ to $\frac{1}{3}$ lb., white arsenic $\frac{3}{4}$ lb., and Paris green $\frac{1}{2}$ lb., to 25 lbs. bran.

The former poison, sodium arsenite, is the one most commonly used, as owing to its great solubility a very even distribution of poison is obtained throughout the carrier, and consequently the amount of poison required for effective work is considerably less than that of white arsenic or Paris green, which are insoluble; as it is much cheaper than either white arsenic or Paris green its use is far more economical. On the other hand, it has been found that baits containing either of the two insoluble arsenical compounds remain active in the field for several days longer than the sodium arsenite bait, which has its effectiveness considerably diminished after heavy rains.

ATTRACTANT.

Special sweet or aromatic substances have often been added to the poisoned bait to increase its attractiveness to the insects. The addition of molasses was recommended by most entomologists who had experimented with poisoned baits, but recent extensive work in Siberia and South Russia has shown that the addition of these special attractive substances is not really necessary, and that as effective results can be obtained without them, as the baits used when prepared are sufficiently attractive in themselves.

Fresh crushed hoppers are often mixed with the bait, thus rendering it more attractive, and as these could be added without any additional cost, which would be incurred by the use of molasses, they are preferable to the latter. Most work with poisoned baits conducted against migrating hopper bands is now done without the addition of any special attractants. They are, however, generally employed in one form or other when laying baits for solitary grasshoppers.

PREPARATION OF POISONED BAITS.

When used against locusts the poisoned baits are prepared during the actual control operations. Poisoning takes place during the early morning and evening, and the middle of the day is generally devoted to preparing the bait.

The bait may be mixed either by the dry or wet method. The dry method is generally used for insoluble poisons, as it ensures an even distribution throughout the bait. This may be done by hand on a hard floor, in which case the poison is gradually mixed into a heap of bait of the required proportions, by continually turning over the heap as the poison is slowly sprinkled over it. Sometimes special machines are used for mixing when the campaign is on a large scale. These machines consist of a large square wooden box, which can be rotated on a shaft like a butter churn, either by machinery or by hand. Large quantities of bait can be thoroughly mixed at one time by this means.

After the dry poison has been mixed in this manner with the carrier, water is gradually added and thoroughly mixed into the bait until it is sufficiently damp.

When soluble poisons (e.g., sodium arsenite) are employed mixing is effected by the wet method. The required amount of poison is dissolved into just enough water to make the whole mixture slightly damp, and the solution then slowly poured over a heap of the carrier and thoroughly mixed with it.

When prepared, the poisoned bait should be slightly damp and even in consistency. It should not contain lumps and should be able to crumble easily when squeezed in the hand, and when distributed it should spread over the ground in a fine even layer.

METHOD OF DISTRIBUTION.

The prepared bait can be stored in bags and transported easily to the places required in the field. Poisoning of hopper bands must take place in close conjunction with their movements. This is generally done when they are stationary and congregated into dense bands for the night, and consequently work takes place in the evening and early morning. Each band is treated separately by scattering bait over it as quickly and with as little disturbance as possible. The operator carries a kerosene tin of the bait and broadcasts handfuls of it over the roosting band, the action being the same as broadcasting clover seed. It should be distributed over the band in an even layer and not allowed to fall in heaps. A second gang of labourers refilling the empty kerosene tins from the supplies of bait in the bags, which are dumped at a central point, keep the

operations continually going without check, until all the bands have been treated.

The hoppers generally feed in the evening before climbing up the vegetation during the night, and again in the morning as they descend to the ground again. They collect in dense groups over the bait and feed on it voraciously, generally remaining on or very near the treated area until they die.

THE USE OF POISONED BAITS IN THE GOLD COAST.

During the present anti-locust campaign in this colony the poisoned bait method is being used so far with success to supplement the primitive and first-aid mechanical measures of trenching and burning. The poison used is sodium arsenite, and the carriers so far employed have been crumbled horse-droppings, the guinea-corn bran known as "dusa," which is left over from the native manufacture of "peto" beer, and chopped-up grasses, particularly one (to be determined) which grows in "fodama" throughout the Northern Territories, and is used by the natives as fodder for their horses. It gives off a faint attractive odour when moistened with water, and is very successful in places where sufficient horse manure or "dusa" is not available.

In mixing the poison solution with this chopped-up grass it was found that a similar proportion of water was necessary to render it sufficiently damp as was needed for the same amount of dried horse manure or "dusa."

The amount of poison used is 4 to 5 ozs. to 25 to 30 lbs. carrier, or one-half to three-quarters of a cigarette tin of poison to two kerosene tins of carrier. Prepared bait is transported to the field from the mixing centres in cacao bags as head loads, the actual distribution taking place by operators, each carrying a kerosene tin of bait. Greatest mortality is found in normal cases to be after twenty-four hours, although this is delayed somewhat longer in thick vegetation. Poisoned hoppers tend to collect in heaps under the shade of bushes and clumps of grasses, and sometimes can be seen clinging to the vegetation itself.

It has been found that heavy showers of rain reduce the effectiveness of the horse manure and "dusa" baits, but in these cases a second light treatment procured the same complete results as with bands treated during fine weather.

These baits have so far been effective on all stages of the hoppers of *Locusta migratoria migratorioides* R. and F., except the first two days after emergence from the egg, and at the time of the final moult of the fifth stage hopper into the adult, when no feeding takes place at these periods.

ADVANTAGES OF THE POISONED BAIT METHOD.

The advantages of the poisoned bait method as a means of locust control are many. Its advantages over the mechanical methods of trenching and burning are at once evident, as the whole band, and not a certain proportion, is completely destroyed with the minimum amount of labour.

Of the chemical control methods used at the present time which aim at a mass poisoning of all the hopper banding it is by far the cheapest. This is due to the very small amount of work necessary for the distribution as compared with other methods, and to the absence of expenditure on apparatus such as spray pumps. Unskilled labour can be used for its application, and this is a very great advantage over spraying, where trained workers and extensive repair centres are needed for successful operations. It can also be used for any type of vegetation and under conditions where it would be impossible to apply other methods.

An objection is raised against this method, as with spraying, that the distributed bait forms a source of danger to live-stock, but this is greatly exaggerated, and little or no danger can accrue from bait spread in the field if carried out in the proper manner. Nearly all cases of live-stock poisoning can be traced to carelessness from not carrying out strict sanitary precautions or by improper spreading of bait.

CONCLUSION.

Although the poisoned bait method is now one of the chief measures employed by all locust-infested countries in the mass poisoning of hoppers, a great deal of research work, of vast importance economically, has yet to be done on the subject. This is especially so in the case of the study of attractants, for very little is yet known as to the actual significance of the phenomenon of positive chemotropism in the Acrididæ.

Economic entomologists who have to conduct poisoned bait operations against bands of hoppers during years of locust invasions have to use the most satisfactory material at hand for use as carriers, and continue with them if successful until all bands have been destroyed. This has resulted in the discovery of a wide assortment of substances which can be successfully used for this purpose, but nothing yet is known as to the cause of their attraction.

Detailed research on a chemical and physiological basis is needed to determine the exact nature of the attractants in the baits commonly used. It has been found that the attractiveness of some baits for Acrididæ vary with the age of the insect, which at different instances may be attracted more to some substances than others. Again, the influence of the temperature has a definite effect

on the habits and movements of these insects, and is thus closely connected with the phenomenon of chemotropism.

It is definitely known, however, that most Acrididæ show a positive chemotropism for water, and this no doubt renders bait attractive when damp, but that some other factor which attracts the hopper also is present can be seen by the marked preference to some baits over others, even if they all contain the same amount of moisture.

It is evident that accurate knowledge of these matters, which can only be accomplished by systematic research, will afford us clearer ideas of the whole phenomenon of chemotropism in the Acrididæ, and will pave the way to more efficient practical measures in the field.

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PAPER No. XL.

HYDNOCARPUS WIGHTIANA AND H. ANTHELMINTICA ON KUMASI EXPERIMENT STATION.

By H. NICHOLAS.

Habitat.—The genus *Hydnocarpus* belongs to the natural family Flacourtiaceæ, and is distributed fairly widely through the tropical evergreen forests of India, Burma and Siam. A number of other genera in the family Flacourtiaceæ are found in West Africa, and a member of the genus *Caloncoba* (*C. echinata*) submitted for trials from Sierra Leone has been shown to produce oil containing chaulmoogric acid. This, however, has at present proved unsuccessful in the treatment of leprosy, possibly due to the absence in the oil of hydnocarpic acid.

Treatment of Leprosy.—From the seeds of both the species *Wightiana* and *anthelmintica* chaulmoogra and hydnocarpus oils are extracted. These oils have long been used in the treatment of leprosy and skin diseases, and provided they are carefully prepared have been proved successful. Various stages of treatment had been adopted before the most recent method was evolved. The patients may be given the seeds to chew, but by this method there is risk of prussic acid poisoning. The first use made of the extracted oils was for them to be given orally ; this proved to be a nauseating process, and intramuscular injection of the oil followed. This was too painful for patients to submit to a prolonged course of treatment, and the next advance was the preparation of the soluble sodium salts of the fatty acids contained in the oils, these being injected either intramuscularly or intravenously. A practical modification of this is the preparation and injection of the ethyl esters of these fatty acids ; and considerable success has been attained with the use of this material in the Philippine Islands and in India.

Results of Trials at Kumasi.—*H. Wightiana* : 230 seeds were received from India through the Botanist in June, 1926, and were sown in nursery beds. From these only fourteen seedlings were raised. This low germination is not remarkable, as it appears that the seed quickly loses its vitality.

The seedlings were planted out in September, 1926, eleven of them in a row at 15 feet intervals, on sloping ground in medium soil overlying laterite in the open, while three were planted in medium soil under fairly heavy shade, such as that required by cacao. The

latter have made comparatively poor growth, with a height of about 7 feet, but are long and straggly, with small lateral branches, and have given no signs of flowering.

Those planted in the open have made remarkably good growth, and at the end of 1929 averaged 10 feet high, with a lateral branch spread of 6 feet and a pyramidal shape. Flowers first appeared in September, 1928, and a few fruits on one tree set ; these, however, failed to develop. Many more flowers appeared in March, 1929, and fruits on three trees set and continued to develop. At the end of 1929 only one tree had failed to flower out of the ten plants surviving, five bearing female flowers or fruits and four bearing male flowers.

From observations up to the present *H. Wightiana* appears to be diœcious, no female flowers have been found on plants bearing male flowers, and no male flowers on plants bearing female flowers. The " female " flowers bear stamens, but these appear to be abortive.

The male flowers are produced in great numbers, in clusters on short axillary branches along the lateral stems. Flowering was practically continuous from March to December, 1929. The female (hermaphrodite) flowers are much less numerous and are produced on similar short axillary branches. So far they have appeared mainly in the months of March and April and December.

So far no fruits have matured, but some appear to be approaching maturity. Apparently the procedure of harvesting is to allow the fruits to fall when ripe and then to collect them. When young the fruit is covered with a blackish velvet tomentum ; later the fruit becomes globular and greyish brown in colour and a hard woody shell develops. The largest fruits found so far are about 3 inches long and $2\frac{1}{4}$ inches in diameter. The fruit examined contained seventeen seeds, irregularly arranged and of irregular angular shape

The plants have made very vigorous growth, and have produced fruits which should mature within three and a half years of the time of sowing the seed. One tree died in 1928 from root disease (Fomes lignosus probably), but no other signs of disease have been noticed. The only insect pest found causing noticeable damage has been a shot-hole borer, which has killed 2 feet of the terminal branches in three cases.

H. anthelmintica.—Seeds which came from Bangkok were received through the Director of Medical and Sanitary Services, Accra, and sown in nursery beds in January, 1928. They germinated in the following March, giving 52% germination, and thirty-six plants were planted out in June. Growth at first was rather slow, and though the plants have come on a lot during 1929, their growth has never been so vigorous as in the case of *H. Wightiana*. At the end of 1929 the average height is 3 to 4 feet, though the best plants

HYDNOCARPUS WIGHTIANA.

FRUIT APPROACHING MATURITY.

are 6 feet high. Branching and leaf production is not so free as in *H. Wightiana.*

Conclusion.—*H. Wightiana* grows well in the forest belt of this country under open conditions. It commences to fruit early, and within a few years enough seed should be produced from the plants already established to warrant the extraction of oil and medical trials. Meantime it is suggested that the seed produced should be used for propagation.

PAPER No. XLI.

THE SECOND IMPERIAL MYCOLOGICAL CONFERENCE, 1929.

(The Gold Coast delegates were Messrs. R. H. Bunting and H. A. Dade, who attended all the sessions. Mr. J. Wright, subsequently appointed Mycologist in this Department, also attended the Conference.)

INTRODUCTORY.

The Second Imperial Mycological Conference was held at the Imperial College of Science and Technology, in London, from September 23rd to 28th, 1929.

The following Dominions and Colonies were represented at the Conference: Canada, Australia, Irish Free State, New Zealand, Southern Rhodesia, India, British Guiana, Ceylon, Fiji, Gambia, Gold Coast, Jamaica, Nyasaland, Sierra Leone, Straits Settlements, Federated Malay States, Tanganyika, Trinidad, Uganda, Palestine, Sudan, Imperial College of Tropical Agriculture, Barbados.

The Conference was opened by the Right Honourable the Earl Buxton, P.C., G.C.M.G. Mr. F. A. Stockdale, C.B.E., the Assistant Agricultural Adviser to the Colonial Office, took the chair at some sessions of the Conference.

The Gold Coast delegates, Messrs. Bunting and Dade, were appointed members of sub-committees on the handling of dangerous material and finance respectively.

All the subjects presented for discussion were suggested by Overseas Governments.

SUBJECTS DISCUSSED.

Material sent in by the various countries for discussion was grouped under fifteen heads as follows :—

Subject I.—Work and organisation of the Imperial Bureau of Mycology.

,, II.—Root diseases of orchard and permanent plantation crops, with special reference to the relative importance of the various fungi concerned.

,, III.—The existing organisation of plant pathological (plant protection) services in various parts of the Empire.

Subject IV.—Field inspection and certification of crops as a basis for the prevention of disease.

,, V.—Virus diseases.

,, VI.—Practical difficulties in the administration of plant protection regulations and the possibility of laying down a standard minimum requirement for preventing the importation of diseased plant material.

,, VII.—Seed-borne diseases, with special reference to (*a*) standard methods of determining percentage of infection ; (*b*) standard methods of seed treatment ; (*c*) legislation governing the export and import of seeds.

,, VIII.—Organisation of spray services based on weather forecasts.

,, IX.—Epidemiology of common and widespread diseases in cereals, including rusts and smuts.

,, X.—Diseases developed in fruit shipped overseas, including bitter pit and storage troubles.

,, XI.—Soil-borne and soil-induced diseases (parasitic and non-parasitic), including those of cereals.

,, XII.—The control of insect pests by entomogenous fungi, with special reference to island conditions.

,, XIII.—Formulation of a standard method of handling dangerous material (specimens and cultures) in mycological laboratories.

,, XIV.—The publication of an abstracting journal for the literature on mycological systematy.

,, XV.—The need for a series of handbooks on the diseases of tropical and sub-tropical crops.

NOTES ON THE DISCUSSIONS.

The programme (A attached) and resolutions (B) indicate the scope and nature of the proceedings. A few notes on the discussions and resolutions follows :—

Subject I.

An account of the work of the Imperial Bureau of Mycology during the last five years was given by the Director, Dr. E. J. Butler. In the discussion that followed several delegates, including the Directors of Agriculture, paid tribute to the value of the Bureau's work, there were no adverse criticisms, and the unanimous feeling of the Conference was to the effect that every facility for the continuance of expansion of the work of the Bureau should be given.

Subject II.

A paper was read by Dr. H. R. Briton-Jones reviewing the work done on *Macrophomina phasedi*—perhaps better known as *Rhizoctonia bataticola*—and its relation to root diseases. A free discussion followed, and the situation as regards the relative importance of this fungus was clearly defined.

Subjects III. and VI.

The discussion on Subject III was opened by Mr. Stockdale, who occupied the chair on this occasion. He directed the discussion on the following lines :—

(i.) Necessity for proper quarantine (in a quarantine station) of "stock" for propagation, *e.g.*, cuttings, bud wood, seeds, etc.

(ii.) Necessity for ample powers to deal with "new diseases." (A "New disease" was defined as "a change in the disease situation" which covers diseases actually previously unknown, and known diseases newly introduced into a country.) Such powers should include those for the prompt putting into action of necessary machinery and group notification, *i.e.*, the transmission of full information to other Colonies in the same natural group or affected by the change in the disease situation.

(iii.) The desirability of recognising certificates and the possibility of defining their significance.

It soon became evident that Subject VI could not be completely divorced from Subject III, and the two were considered together.

During the discussion Messrs. Wortley and Dade remarked on the advantages in small colonies of total prohibition of all plant imports, with certain exceptions, as a simpler and more effective alternative to the prohibition of scheduled plants and diseases. Such legislation is in force in Nyasaland, and its advantages in small colonies were supported by other delegates.

Mr. Freeman described the legislation in force in Trinidad, and pointed out the great practical advantages of plastic legislation, which enabled the authorities to take immediate steps, in emergencies, without the waste of time necessary in cases where it is necessary for departmental authorities to obtain special powers.

The hands of Directors are, in some cases, so tied by black and white regulations as to render their efforts to deal with emergencies abortive owing to delay.

The difficulties connected with certain forms of certification were discussed. In the forms generally in use the inspector has to certify that certain plant materials are absolutely free from all diseases ; such a certificate cannot be conscientiously given, and it does not provide importers with definite information. An alternative standard form was proposed by the Conference, a copy of which is appended to the resolutions, and is referred to in Resolutions 7 and 7A.

The question of the exclusion of witch-broom disease of cacao from West African Colonies was brought up by Dr. Butler. In view

of the peculiar situation of West African Colonies, *i.e.*, the extensive French land frontiers, Resolution 4 was adopted, and Mr. Stockdale was asked to put the matter before the Second West African Conference in order to determine whether some satisfactory joint organisation could be instituted.

During the discussion on Mr. Stockdale's proposals for group notification (Resolution 6) it was pointed out that the West African Colonies form a natural group.

Resolutions 3, 4, 5, 6, 7, 7A and 8 resulted from these discussions.

(Official name of Inspection Service and address.)
Certificate No.

CERTIFICATE OF INSPECTION.

THIS IS TO CERTIFY that I: (name and position and address of authorized official) have to-day and immediately prior to shipment thoroughly examined a representative sample of the living plants of plant products for which this certificate is required, contained in the following consignment(s): (description of consignment), stated to have been grown at (locality where grown), where the said plant or plant products have/have not been inspected in the field, etc.
AND THAT I have been unable to discover any evidence of the presence of any insect pest or plant disease in said shipment, except as follows :— .....
.....
In particular, the following pests or diseases have been looked for and not found.....
.....
The consignment covered by this certificate has been treated in the following manner :—

X Official Seal.

Date of issue :
Place of issue :

Subject IV.

Dr. Güssow read a long and detailed paper on the very highly-organised systems of inspection and certification employed in Canada, with statistics showing their effect on prevention of disease.

Subject V.

Several delegates read papers on work done on virus diseases, principally those of potatoes. Facts of interest were the obvious close relation of all the virus diseases of potatoes, the earlier yield of crop, the smallness of which is in some cases more than compensated for by higher prices for early potatoes, the attenuating effect on the crinkle virus obtained by passing it through *Datura* as an intermediate host, the opposite effect produced by tobacco under the

same circumstances, the sole significance of the aphis, *Myzus persicæ* in all these virus diseases, the history of the virus in the insect, and Henson Smith's work proving intracellular bodies associated with virus diseases to be artifacts and not organisms.

A description of cotton leaf-curl in the Sudan was given by Mr. Massey. (This is the virus disease first described by G. H. Jones in Nigeria.) The only vector is a Jassid, which is dependent on a dry atmosphere for breeding. *Hibiscus esculentus* is a symptomatic host.

Subject VII.

This subject, introduced by Mr. Cunningham, dealt with several difficulties experienced in the control of spread of seed-borne diseases by importation, and led to Resolution 9.

Subject VIII.

See Resolution 13. Messrs. Wiltshire and Murphy's papers (on potato diseases) showed that a great deal more exact meteorological information is required before forecasting of disease outbreaks can be efficient. During the discussion Mr. Dade drew attention to the situation in the Gold Coast, where the Department of Agriculture itself has control of the collection of meteorological data, and a Division of Meteorology in close touch with other divisions, a most desirable arrangement.

Subject X.

The papers and discussion on this subject were mainly concerned with factors inducing physiological disorders in apples in transit and cold storage.

Subject XI.

The papers read on this subject dealt with serious affections of cereals and sugar-cane traced respectively to manganese deficiency and excess of magnesium salts in soil, and with the effect of cultural treatment on Panama disease of bananas.

Mr. Belgrave drew attention to the necessity for certain precautions in *p*H determinations and to the fact that lime or sulphur, for example, added to soil to adjust reaction, produce conditions additional to those of hydrogen-ion concentration.

Papers.

Papers were read by Professor Ashby and Mr. Freeman on the witch-broom disease of cacao, with special reference to the situation in Trinidad. The evidence indicated that the outbreak in Trinidad was due to the introduction of spores from the mainland by wind. Owing to the prompt measures taken by the Department of Agriculture, there is good reason to believe that the disease is under control and will be successfully controlled in future without serious difficulties or loss.

A paper was also read by Mr. R. H. Bunting on the newly-instituted Stored Products Research Laboratory of the Empire Marketing Board at Slough. In the course of his paper Mr. Bunting described briefly some of the recent work done in the Gold Coast on cacao moulding. Mr. Dade, speaking on Mr. Bunting's paper, referred further to Gold Coast work, and indicated the uses to Colonies of the Slough institution in co-operation with overseas workers on defects of produce, in standardisation of methods of determining quality, and in keeping in touch with manufacturers' requirements.

Mr. Freeman described the breeding in Trinidad of a lime immune to wither-tip disease.

Subject XII.

The discussion on this subject, which was opened by Mr. C. B. Williams, emphasised the conclusions already clearly stated by Petch, *i.e.*, that attempts to introduce infection of insect pests by entomogenous fungi on a large artificial scale are not generally useful. An interesting point which was developed, however, was the possibility of control of natural conditions affecting normal parasitisation, as for example, the institution of windbreaks which maintain a still, humid atmosphere favourable to the activity of the fungi.

Subject XIII.

This subject is dealt with in Resolutions 10, 11 and 12 at the end of this paper.

Subject XIV.

This is dealt with in Resolution No. 1 of the Conference at the end of this paper.

Subject XV.

The Committee begs to report that it is of opinion that a series of handbooks on the diseases of the most important tropical and sub-tropical crops is needed ; and they recommend that :—

(1) The following crops should be dealt with in this series :—

(*a*) Sugar-cane.
(*b*) Cacao.
(*c*) Tobacco.
(*d*) Cotton.
(*e*) Coconut and other palms.
(*f*) Bananas and other fruits (excepting citrus fruits).
(*g*) Tropical cereals and rice.
(*h*) Ground provisions.
(*i*) Coffee.
(*j*) Rubber.
(*k*) Tea.

(2) Each handbook be compiled by an Editor to be selected by the Imperial Bureau of Mycology and that, where the Editor is a member of

a Colonial Government Service, duty leave should be granted him to facilitate the preparation of the book.

(3) Each handbook should be written in language suited to the needs of more advanced planters, with all important technical material incorporated in smaller type.

(4) Each Editor will draw fully on all previous published work, giving references, for a general account of each disease, and shall endeavour to obtain by means of questionnaires any additional information he may require from Mycologists in the Colonies and Dominions.

(5) In each handbook special attention be devoted to such aspects of diseases as :—

(*a*) the relation of disease to varied agricultural practice ;

(*b*) varietal resistance to disease, naming resistant varieties in detail ;

(*c*) agricultural methods of control as distinct from such methods as spraying and dusting ;

(*d*) good illustrations and accurate description of each disease.

(6) In each handbook such matters as the existence of gaps either in our knowledge of any disease or in the development of control measures suitable for use under tropical conditions should be indicated, as suggesting lines for future research.

(7) The Imperial Bureau of Mycology should supervise the organisation and publication of the series and act as General Editors.

(8) With reference to publication, the Imperial Bureau should approach the Colonial and Dominion Governments particularly interested in each handbook, as well as large commercial interests, for a subsidy to enable the handbooks to be sold at such a price as would appeal to planters.

(9) Finally, the Committee wishes to emphasize that the series must be of outstanding merit, otherwise it would be preferable to drop the scheme altogether.

EXCURSIONS.

The excursions to East Malling and Long Ashton, arranged in connection with the Conference, were of very considerable interest.

These two excursions were particularly interesting to Gold Coast representatives because the work in progress on apples (and other orchard crops) is very suggestive, many problems being of a similar nature to those affecting cacao, particularly the effect of cultivation on the physiology of the trees and the quality of the crop.

At both stations much work has been done on grafting and the remarkable effect of the work on the resulting tree.

Results of extreme interest to those interested in cacao have been obtained by T. Wallace and others in very detailed work at Long Ashton on apples and other fruit crops with regard to the effect of soil deficiencies. These effects are very marked, and a complete system of symptomatic diagnosis has been evolved whereby soil characteristics can be immediately recognised from the appearance of foliage, etc. A simple method of check by analysis of certain parts of the plant (terminal shoots, etc., not fruit) has also been worked out, the results of which show remarkable correspondence with the results of soil analysis.

Professor Barker demonstrated the latest results in research on the fungicidal effect of sulphur. Briefly, this effect is now known to be due to the production of H_2S by the action on the sulphur of some substance which passes out from leaves through stomata, and, further, to the action on the sulphur of some substance produced by the fungi themselves.

Two demonstrations at Long Ashton of considerable interest to entomologists and mycologists were :—

(i.) The extreme efficacy of Agrol WB (a sulphonated oil produced by Imperial Chemical Industries) in emulsifying tar distillate or any oily fluid. Ten per cent. of the substance produces complete emulsification.

(ii.) The efficacy of Agrol I as a wetting agent : this substance is four times more efficient than soft soap and seventy times more efficient than caseinate.

While at Bristol delegates were able to attend meetings of the British Mycological Society, and Mr. Dade also took the opportunity of visiting Fry's Cacao Factory and discussing the moulding problem with Mr. E. E. Holloway, of that firm.

Cambridge.

At Cambridge experiments on virus diseases and silver leaf disease were shown to delegates, and the cold storage research laboratories were visited.

The Research Stations at East Malling and Long Ashton are well worth a visit by members of the Department of Agriculture when on leave.

RESOLUTIONS.

The following resolutions were unanimously adopted by the Conference :—

Resolution 1.

That this Conference urges that the necessity for an abstracting Journal of the world's literature on Mycological Taxonomy be referred to the International Botanical Congress, Cambridge, 1930.

Resolution 2.

That this Conference accepts the report of the Committee appointed to consider the need for a series of handbooks on the diseases of tropical and sub-tropical crops and recommends that it be referred to the Managing Committee of the Imperial Bureau of Mycology for such action as may be necessary to give effect to it.

Resolution 3.

With a view to protecting the staple agricultural crops of a country, this Conference recommends that the Government thereof should include in its Plant Protection Legislation provisions for growing under quarantine stock for propagation capable of introducing diseases which may

affect such staple crops, and should take measures to ensure that such quarantine can be effectively carried out by or under the supervision of the agricultural authority.

Resolution 4.

The Conference notes the recent outbreak of witch-broom disease of cacao in Trinidad and suggests that the attention of the British West African Colonies should be drawn to the desirability of co-operating with neighbouring countries in West Africa in devising steps which will satisfactorily provide against the possible introduction of this disease into West Africa.

Resolution 5.

The Conference suggests that the attention of the Governments of Malaya and Ceylon should be drawn to the desirability of investigating the possibility of treating bud-wood of rubber against diseases before import.

Resolution 6.

In order to facilitate protective legislation and possibly to further our knowledge of the means by which diseases spread or are introduced from one country to another, it is desirable to obtain in a form readily accessible and up to date, full information in regard to the distribution of diseases of crop plants throughout the world. For this purpose, this Conference recommends that provision be made for the necessary work to be undertaken at the Imperial Bureau of Mycology and that the tropical Colonies should make arrangements for group notification.

Resolution 7.

This Conference is of opinion that the system of certificates is one which should be universally recognized, but that the acceptance of such certificates should not be allowed to imply that importing countries should in any way waive their right of prohibiting, inspecting, treating, quarantining and destroying where necessary, plant imports. It further recommends that steps should be taken to arrange that exporting countries within the Empire should specify as nearly as possible the significance of their certificates covering plant exports.

Resolution 7a.

This Conference also recommends that the form of certificate of inspection appended (see p. 343) be submitted for approval to the Ministry of Agriculture and Fisheries in the first instance and then to the Dominions and Dependencies within the Empire and, if approved, that it then be adopted.

Resolution 8.

This Conference recommends that countries between which planting material frequently passes should endeavour to group themselves together and investigate the possibility of finding a minimum treatment for any specific pest or disease of a particular plant of which the export is required.

Resolution 9.

That research work relative to the important question of seed-borne disease be given increased attention throughout the Empire, if necessary by the appointment of one or more specialists to the respective plant pathological services, and that such investigations be co-ordinated with the duties of seed-testing stations.

Resolution 10.

That this Conference approves the draft prepared by the Committee appointed to formulate a standard method of handling dangerous material (specimens and cultures) in mycological laboratories and recommends that it be circulated to mycologists throughout the Empire.

Resolution 11.

That special care be taken in the handling of dangerous specimens in mycological laboratories where teaching is carried on.

Resolution 12.

That teachers of plant pathology, if they do not do so already, give careful consideration to the possible risks of introducing cultures of plant pathogenic organisms into countries where diseases caused by those organisms do not occur.

Resolution 13.

The Conference, appreciating the valuable help that has been given to the Plant Protection Services by the Meteorological Departments in various parts of the Empire, urges the need for further co-operation and, especially, for the more precise formulation by plant pathologists of the data which they would like to obtain.

Resolution 14.

The Conference expresses warm appreciation of the services rendered to mycology and plant pathology by the Centraalbureau voor Schimmelcultures at Baarn, under the direction of Professor Westerdijk, and desires to bring them prominently to the attention of mycologists and plant pathologists throughout the Empire, in the hope that means may be provided for continuing and developing the work of the Bureau on a still more satisfactory basis.

Resolution 15.

The Conference wishes to place on record its views of the desirability of the republication of certain important mycological works that can no longer be obtained, and requests that the necessary steps should be taken to ensure that this matter is discussed at the International Congress at Cambridge in 1930.

Resolution 16.

The members of the Imperial Mycological Conference desire to place on record their appreciation of the very efficient and sympathetic work of the Executive officers of the Bureau in securing the success of this Conference, and they desire to convey to Dr. Butler and his staff their thanks for their unremitting efforts in bringing about this success.

Resolution 17.

That this Conference reaffirms the fifth resolution adopted at the First Imperial Mycological Conference, namely, that in view of the benefits derived from an exchange of views between overseas mycologists, Conferences similar to the present one should be held every five years.

PAPER No. XLII.

THE CONFERENCE OF EMPIRE METEOROLOGISTS, 1929.

(The official delegate to the Conference was Mr. N. P. Chamney, Officer-in-Charge, Division of Publications and Meteorology, while Mr. G. G. Auchinleck, Mr. R. H. Bunting, Mr. A. C. Miles and Mr. H. Nicholas attended as visitors.)

The Conference was arranged by the Air Ministry (Meteorological Office), and was held in London from August 20th to September 4th, 1929.

The Empire Marketing Board, on learning that the Conference had been arranged, consulted the Ministries of Agriculture for England and Wales, Scotland and Northern Ireland, with the result that a section dealing with Agricultural Meteorology was formed with the consent of the Meteorological Office.

COMPOSITION OF THE CONFERENCE.

The Conference was divided into two sections :—

(1) General meteorology.
(2) Climatology and agricultural meteorology.

The sessions of the first section were held in the Air Ministry (Meteorological Office), under the chairmanship of Dr. G. C. Simpson (Director of the Meteorological Office), and were attended by twenty-three delegates from the Dominions and Colonies, together with certain of the staff of the Air Ministry and some visitors.

The sessions of the second were held in the Hall of the Civil Service Commission, Burlington Gardens, under the chairmanship of Sir Napier Shaw. These sessions were attended by the delegates to the General Conference and by ninety-two additional delegates and visitors from the Colonies and Great Britain.

Seven Dominions, eighteen Colonies, India, Egypt and the Sudan were represented, in addition to the British Isles.

GENERAL WORK OF THE CONFERENCE.

The Conference was opened on August 20th by Lord Thomson, Secretary of State for Air, who emphasised in his speech the necessity for uniformity of methods, observations and records.

The sessions of the first section were confined to the reading of papers by the heads of the various divisions of the Meteorological Office, and to discussion by the delegates of the points raised in these papers. The need of accurate data for Air, Naval, Military and Merchant Services was emphasised, and the various classes of observations dealt with in detail. The organisation of a Meteorological Service for all these different heads was well demonstrated in theory and practice.

A number of sub-committees were appointed to discuss in detail meteorological requirements on various air routes, and among these a sub-committee on West African meteorology was formed. The Director of Agriculture and Mr. Chamney served on this committee, and the final resolution passed by the Conference on the recommendation of this sub-committee will be found in Appendix I (Resolution I).

It seems unnecessary to deal with this side of the Conference further, as the proceedings did not cover agricultural matters.

GENERAL CLIMATOLOGY.

The first and second sessions of the Joint Conference were occupied by the papers on General Climatology and by discussions on them.

(1) Mr. R. K. Lempfert read a paper on International Meteorology, and in the discussion which followed, the necessity for uniformity of records for publication in the Reseau Mondial and Colonial Bluebooks was dealt with.

(2) Dr. C. E. P. Brooks gave the ideas of the Meteorological Office on the collection, tabulation and publication of data. Much discussion followed on the type of data required, the period best suited to the formation of means and the frequency of publication. The value of the study of diurnal variation from the point of view of agriculture was brought out.

(3) Mr. Chamney read a short note on West African rainfall and the amplification of rainfall data.

(4) Sir Gilbert Walker's memorandum on Long Range Forecasting, together with Mr. Brunt's note on Periodicity, were fully discussed. Every meteorologist is expected to forecast, and the various methods by which any correlation can be obtained were dealt with in detail. The opinion of the meeting was that as methods must differ in every country there can be no universal system and every country must work out its own method.

AGRICULTURAL METEOROLOGY.

(1) The sessions of this section were opened by Sir Napier Shaw with a brief historical review of the subject. Following from his speech he brought forward a resolution on the necessity of more education in the science. Resolution by the Directors of Agriculture (Nyasaland and Gold Coast) on Education in Agricultural Meteorology and the formation of a Bureau on this subject were then dealt with (see Appendix I.).

(2) The second paper by Sir Napier Shaw dealt with the week as a meteorological unit.

The discussion was keen, and a sub-committee was found, on which the Director of Agriculture (Gold Coast) served.

The Director of Agriculture (Gold Coast) urged the adoption of a week, while the question of five-days means was also discussed.

(3) Professor Blackman's paper showed the relation between Meteorology and Plant Physiology, and a resolution of co-operation between the sciences was passed.

(4) The Varietal Response of the Plant to Length of Day, by M. A. Tinker.

(5) A note on the Relation between Weather and Crops, by A. Walter (East Africa).

(6) Climate, Crops and Soils in British Tropical Colonies, by F. J. Martin (Sierra Leone).

These papers were not read.

(7) Mr. Hornby's paper on Weather and Tobacco showed that tobacco grows in Nyasaland with twice the rainfall which is considered optimum in America.

(8) Dr. Atkins and Dr. Poole gave a most interesting account of their research into the measurement of daylight. During the discussion the Director of Agriculture (Gold Coast) pointed out the value of such work in determining planting distances of such crops as cacao.

(9) Two papers by Messrs. Taylor and Turnbull gave the position with regard to the meteorological needs of the fruit producer. As these papers dealt only with temperate climates, they lost a certain amount of interest.

(10) The relation of animal numbers to climate was dealt with by Mr. Elton.

(11) The entomological side was given by Mr. Uvarov and Mr. de Gryse (Canada).

The needs of entomology with regard to self-recording instruments and education of students of that science in the value of meteorology were clearly explained as well as a detailed account of the effect of climate on insect life.

(12) Mr. Foister dealt with the Effect of Weather on Fungi. The need of the mycologist is clearly the study of the climate in the immediate vicinity of the plants under observation, and the meteorologist must supply suitable instruments to carry out the work. The question in both the entomological and mycological one is also administrative in the forecasting of insect or fungoid attacks by the study of meteorological conditions.

(13) Crop forecasting was the basis of Mr. Irwin's paper. He had evidently gone deeply into the subject, but the statistical treatment given was only possible under the conditions obtaining in civilized countries when data are available for a long period.

(14) Crop weather data in India and their statistical treatment, by S. M. Jacob (Nigeria).

(15) Weather and Wheat Yields at Lincoln College, New Zealand, by Dr. E. Kidson.

These papers were not read.

In general, it may be stated that the discussions in this section brought out clearly the many ways in which meteorology may be

applied to the needs of agriculture and its applied sciences. For this reason the definition of Agricultural Meteorology made by the Conference is reprinted in full as Appendix.

EXCURSIONS.

The delegates to the General Conference were taken to the following places of interest :—

(a) Croydon Aerodrome.

The system of meteorological services to air pilots was shown and the methods whereby the routes that are to be followed are determined and given to the pilot before starting and also in the air. The delegates were also given a flight in an air liner.

(b) Cardington Aerodrome.

The meteorological data affecting airships in flight and at the mooring mast were shown, and the delegates were shown over the airship R.101, the mooring tower and the fabric-preparing sheds. A demonstration of the hydrogen apparatus for filling airships and pilot balloons was also given.

(c) Kew Observatory.

The afternoon spent in visiting this large Meteorological Station was of great use and much valuable information was obtained.

The delegates also visited divisions of the Meteorological Office and were given an opportunity of seeing the Hollerith system of tabulation of meteorological data and logs. In the agricultural section visits were also made.

(*a*) Royal Horticultural Society's Garden at Wisley.
(*b*) Lord Wandsworth Agricultural College.
(*c*) Rothamsted Experimental Station.

At each centre the special instrument employed in the British Agricultural and Horticultural Meteorological scheme of crop forecasting were demonstrated. The drain gauges and large scale raingauge at Rothamsted were of special interest.

APPENDIX I.

RESOLUTIONS PASSED AT THE CONFERENCE.

The resolutions affecting West Africa in the first section of the Conference, and Agricultural Meteorology in the second part, are given below :—

Resolution I.

That in view of the urgent importance of full meteorological knowledge for the development of aviation in addition to the value of meteorology to agriculture and medicine, it is recommended that Nigeria should have a full-time Meteorological Officer, to be appointed on the advice of the Air Ministry.

The Conference is of opinion that other West African Colonies should be invited to avail themselves of the services of the aforesaid Nigerian Officer, who should co-ordinate meteorological data in relation to Aviation, Agriculture, Medicine, etc., for all West African Colonies.

The Week as a Unit.

Resolution II.

In the opinion of the Conference the month is too long a period for the purpose of summarising, for publication, statistics of agricultural meteorology, and the week should be adopted for that purpose.

Instruction in Meteorology and Agricultural Meteorology.

Resolution III.

In view of the fact that technical information regarding weather has become a part of common life, and the information is of little value to those who have no knowledge of the meaning and implication of the technical terms used, the Governments of the Empire should be invited to take into consideration the desirability of making suitable provision for instruction in the physics of the atmosphere and the geography of weather in their national systems of education.

Instruction in the methods and results of agricultural meteorological research should form a more important part of the curriculum, than is the case at present, at University Departments of Agriculture, Agricultural Colleges and Farm Schools.

Experimental and Demonstrational Work in Agriculture.

Resolution IV.

Experimental and demonstrational work, particularly that on cultivation operations, manuring, and varieties of crops, should be accompanied by adequate meteorological observations, since such experimental and demonstrational work loses much of its value unless the results are discussed in the light of the meteorological conditions experienced during the course of the work.

Clearing Station for Information on Agricultural Meteorology.

Resolution V.

The Conference considered the question of the establishment of a clearing station for information on methods and results of Agricultural Meteorological work. The following existing bureaux already, or will shortly, centralise information regarding the problems of the agricultural meteorological research worker, so far as their respective sciences are concerned, viz., the Imperial Bureaux of Soil Science, Animal Nutrition, Animal Health, Animal Genetics, Entomology, Mycology, Plant Genetics (both general and herbage crops), Agricultural Parasitology and Fruit Production. The bulk of agricultural meteorological research work is probably covered by these bureaux.

At the same time, it would be very convenient if all the information on the subject could be focussed at some one centre. Such centralisation of information with subsequent distribution would be useful, both to the agricultural meteorological research worker and to the worker in pure meteorology.

With a view of obtaining experience which will prove useful as a guide to the Imperial Agricultural Research Conference of 1932 in considering the question, the Conference would be glad if the Ministry of Agriculture and Fisheries could develop the work it is already doing in this connection, and could obtain from the existing bureaux, and from other sources, information on the methods and results of agricultural meteorological research, and could issue this information regularly to workers in agricultural science and pure meteorological science throughout the Empire.

This recommendation should not be taken as in any way pre-judging the issue for the Imperial Agricultural Research Conference of 1932.

Fruit.

Weather and Soil Surveys; Frost Damage and Varietal Susceptibilities.

Resolution VI.

Surveys should be initiated or extended in the different parts of the Empire, to determine :—

(i.) the effect of varying weather conditions on the growth, cropping and resistance to diseases and pests of fruit grown on soil of various types, and

(ii.) the positions, under various conditions, in which it is advisable to plant fruit, owing to risk of frost damage.

Further research should be carried out to determine the degree of susceptibility to frost damage of the chief commercial varieties of fruit and to discover the characters which confer resistance to frost.

Variation in Numbers of Wild Animals.

Resolution VII.

In the opinion of the Conference the economic importance of fluctuations in the numbers of wild animals, such as mice and rabbits, justifies the prosecution of research to ascertain the causes of these fluctuations, and in such research it appears essential there shall be close co-operation between the meteorological and the biological research worker in order to ascertain how far these fluctuations are due to climatic causes.

Meteorological Observations of Local Climates.

Resolution VIII.

The Conference are of opinion that the standard records of meteorological components form the base-line to which all investigations on agricultural meteorology must necessarily be related.

But the local climate or weather in the immediate vicinity of the plant or insect in an agricultural crop or elsewhere may be markedly different from that shown in the meteorological screen, and while the Conference recognise that the records of such local meteorology must be made by the individual investigator for individual purposes, they nevertheless are of opinion that meteorologists could render valuable service to agriculture by assisting agriculturists to devise standard methods for adoption in the systematic recording of these local climates, and by studying the results as meteorological data.

Such recording requires appropriate instruments and screens for measuring the meteorological components among various crops in various horizontal strata, above and below ground ; the latter in order to record the environment of the root system.

The standard records should be systematically extended, as opportunity offers, to embrace, e.g., the intensity and quality of solar radiation and the moisture content of soil.

Insect Pests and Plant Diseases.

(*a*) Forecasts, Spraying Advice, Description of Intensity of Attack.

Resolution IX.

The Conference emphasise the value to practical agriculturists of forecasts and seasonal appearance of insect pests and plant diseases and their outbreaks, and recommend that research directed to the discovery of the relations between the various meteorological factors and insect activities and plant diseases should be energetically pursued with a view to providing bases for such forecasts.

The Conference note that entomologists and mycologists are investigating methods for determining and describing the intensity of attack of insect and fungous pests on crops, and express the hope that it will be possible for standard methods to be established.

(*b*) Insect Investigations.

Investigations should be carried out on the following subjects :—

(i.) The application of the climograph method to studies in the distribution, seasonal cycle of development, and periodic fluctuations in the numbers of insects.

(ii.) The effect of atmospheric motion on the distribution of insects.

(iii.) The insect fauna of the upper atmosphere.

(iv.) The influence of coloration of insects on their thermal economy.

(v.) The effects of atmospheric pressure on insect activities and development.

(vi.) The part played by light in the development of insects.

The development of work along these several lines is dependent upon the co-operation of research meteorologists with entomologists, capable of dealing with the physiology of insects.

(*c*) Plant Disease Investigations.

An investigation should be carried out by plant pathologists in close co-operation with meteorologists to determine the distribution of fungus-spores by the wind.

The Conference emphasise the need for close co-operation between phenological mycologists and research workers engaged in investigations on the relation of weather to healthy crop growth and yield.

For the purpose of correlation of weather conditions with plant diseases, the Conference consider it to be very desirable

that continuous records from self-recording instruments should be available. It is particularly important that records should be taken of night temperature.

Crop Forecasting.

The Conference have noted with satisfaction the progress that has been made in the use of statistics of weather in forecasting crop yields, and express the opinion that it is desirable that further investigations should be made into the possibility of improving forecasts of crop yields by this means. Resolution X.

APPENDIX II.

THE SCOPE OF AGRICULTURAL* METEOROLOGY.

The Conference † accepted the following definitions of the scope and methods of Agricultural Meteorology.

Meteorology may be regarded as comprising climatology, which deals with summaries of weather for selected periods, and "weather," which treats of the conditions of the atmosphere from time to time.

Agricultural meteorology is concerned with the effects of climate and weather on agricultural processes. It not only seeks to discover those effects but to draw the maximum benefit for practical agriculture. It attempts to put the knowledge of the atmosphere to practical agricultural use.

The search for the influences of meteorological conditions in agriculture is carried out under four main heads :—

(*a*) *Soils.*—Soils are largely formed under meteorological influences. Climate and weather affect both their chemical and mechanical composition ; the organisms they contain ; and their capacity for retaining and giving up heat and moisture, and plant nutrients, whether originally contained or added in manures. The weather affects the resistance of the soil to cultivation and harvesting operations.

(*b*) *Crops.*—Quite apart from the influence of soils on crops, the weather begins to have an influence upon crop yields almost two years before these yields are harvested, since the quality of the seed used for the crop is determined by the weather of the year in which it is produced. Then, again, the weather of the crop year influences in some cases the manner in which the crop behaves during storage or under subsequent manufacturing processes ; and the weather experienced during storage must similarly be taken into account ;

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* Throughout this Report "Agricultural" includes "Horticultural."

† Throughout the Appendices of this Report "the Conference" is used to mean the Agricultural Section of the Conference. The decisions were taken by meteorologists and agriculturists jointly.

so that in the case of crops more than the weather of the crop year is in question.

During that year, however, the crop is affected in every stage of its development; in its susceptibility to insect and fungous pests and in its final yield both in quantity and quality.

(*c*) *Animals.*—Weather affects animals, both directly and through the crops on which they feed and the soils on which they are kept. It affects their health, growth, rationing and fecundity; their distribution; the yield and quality of animal products; the preparation of these products; and their capacity for storage and transport.

(*d*) *Pests and Diseases of Crops and Animals.*—In addition to influencing the susceptibility of crops and animals to attack by pests and diseases, the weather profoundly affects the kinds of insects and diseases concerned, the numbers and activities of insects and the quantity and virulence of diseases.

As regards the application in practical agriculture of meteorological information and the results of agricultural meteorological research into the questions noted in paragraph (4), there may be instanced :—

(*a*) The use of weather forecasts in planning farming operations day by day, *e.g.*, the employment of labour on indoor or outdoor work; planning of ploughing, seeding, spraying and harvesting.

(*b*) The use of climatological data in planning the whole economy of the farm, *e.g.*, proportion of arable and pasture; kinds and varieties of crops; kinds, numbers and management of live-stock; amount and kinds of machinery; amount of labour and ratio of permanent to casual labour.

(*c*) The use of climatological data in special agricultural engineering problems, such as use of wind and water power, and provision of water.

(*d*) The use of the results of past crop-weather research, in conjunction with current meteorological records, for the purpose of forecasting yields of crops.

(*e*) The use of the results of past research into the effects of climate and weather on insect pests and fungous diseases, in conjunction with current meteorological records, to forecast seasonal occurrence and mass outbreaks of pests and diseases.

(*f*) The employment of protective devices against adverse weather.

The preparation and issue of weather forecasts, as well as the investigation of weather cycles, is to be regarded as in the domain of the meteorologist. The agricultural meteorologist is concerned with the utilisation of the results of this work in practical agriculture.

METHODS OF AGRICULTURAL METEOROLOGICAL RESEARCH.

The methods by which agricultural meteorological research may be carried out include the following :—

(*a*) Laboratory studies with plants, and analogous studies with animals, under completely controlled conditions, of the effect of different

conditions of temperature, humidity, light, etc., in conjunction with different soils and different conditions of nutrition.

(*b*) Pot culture studies, in which factors other than the weather are controlled, and statistical methods are used to ascertain the effect of the different weather factors.

(*c*) Field studies, in which measurements of crop growth and yield and intensity of attack of diseases and pests, on the one hand, and of meteorological factors on the other, are carried out side by side. Analogous studies on animals are carried out by observations on the health, fecundity, etc., of herds and flocks, in conjunction with meteorological records.

(*d*) Statistical studies in which records of yields of crops and weather over a long series of years are correlated.

PAPER No. XLIII.

THE HOURLY DISTRIBUTION OF RAINFALL IN THE GOLD COAST.

By N. P. CHAMNEY.

The question of diurnal variation of meteorological elements has been rendered easy by the introduction of self-recording instruments. Unfortunately, such instruments are costly and difficult to maintain in good working order without trained supervision. This supervision is difficult to obtain in the Colonies, so that the method resorted to in this case has been by observation and noting of the period of rainfall in the remarks column of the record books. While not mathematically precise, the figures are near enough for such generalisations as have been attempted.

The diurnal variation in barometric or thermometric readings differ from the hourly distribution of rainfall in that there are readings available all through the twenty-four hour period whereas many days occur without rain. For this reason the hours of fall and amount of fall have been calculated for periods of one year and presented as percentages of the annual total.

Distribution of Stations.

Owing to various causes it has been impossible to obtain figures over a sufficiently long period for more than three stations in the Colony.

These three stations, viz., Accra, Asuansi and Kumasi, are in three districts which differ widely in relation to their climate. Accra and Asuansi are both south of the forest country, but Accra is coastal and Asuansi twenty miles inland. Asuansi and Kumasi are both on the edge of the forest, the former being at the southern edge and Kumasi on the northern edge. The relation between the rainfall of the three stations is given in Table I.

TABLE I.

Station.	Climate.	Average Annual Rainfall Inches.	Average Number of Wet Days.	Average Number of Rain Hours.
Accra ..	Coastal savannah	27.43	54	123
Asuansi ..	Transitional forest	50.07	123	373
Kumasi ..	Forest	58.50	113	396

DISTRIBUTION OF RAIN—HOURS

Survey H.Q. Accra 1930.

From the above table it will be seen that these stations give an idea of the three main types of climate found in the Gold Coast, with the exception that Kumasi is not quite typical of the real forest country.

Distribution of Rain Hours.

The frequency distribution of rain hours for each station is shown in the accompanying graph, which gives clearly the variation in the distribution at each station. The figures have been obtained from the means of two years' records only, but each year has shown practically exactly similar distribution which can hardly be attributed to chance. These figures as percentages of the annual distribution are given in Table II and will verify the statement.

It will be seen that in Accra the tendency is for rain to fall before noon and at Kumasi in the evening, while Asuansi is intermediate between the two extremes. It is well known that monsoon rains tend to fall in the morning and that after noon the rain is chiefly of the instability type. The monsoon wind in the Gold Coast is from the south-west, and would therefore affect the coastal stations more than those in the interior, of which latter Kumasi is a type.

Distribution of Actual Rainfall.

It is unfortunate that, in the absence of self-recording gauges, it was impossible to work out the amount of fall recorded in each hour, as this would have given very useful figures to compare with the frequency of rain hours. In the absence of these data the question has been approached from a different standpoint.

Period of Effective Fall.

The question of the value of total rainfall figures is a large one and need not be gone into here. It, however, appeared of interest to see how much of the total precipitation fell in hours which might reasonably be considered to give sufficient time for the rain to soak into the ground before the sun had time to evaporate a large percentage of it.

The period fixed on can only be arbitrary, but it suffices to bring out some interesting points. The actual hours chosen were from 4 p.m. to 4 a.m. as the most effective period, and from 4 a.m. to 4 p.m. as the period during which the sun might most reasonably be expected to exert an adverse influence. Objections may be raised on the ground of dull days, but even in this case the temperature will have at least some effect.

At Accra, where a sunshine recorder is in use, forty-four days were recorded over the period 1928–29, and of these twenty-nine were rain days.

Table II gives the number of rain hours and the total fall for each of these periods at each station for each year considered, calculated as percentages of the whole.

TABLE II.

	Accra.			Kumasi.			Asuansi.		
Year.	% Fall 4 p.m. to 4 a.m.	% Fall 4 a.m. to 4 p.m.	* Indefinite.	% Fall 4 p.m. to 4 a.m.	% Fall 4 a.m. to 4 p.m.	* Indefinite.	% Fall 4 p.m. to 4 a.m.	% Fall 4 a.m. to 4 p.m.	* Indefinite.
1928	76.9	20.5	2.6	76.8	22.5	0.7	47.8	51.3	0.9
1929	61.0	32.4	6.6	77.4	22.6	0.0	47.6	49.6	2.8
	% Rain hours 4 p.m. to 4 a.m.	% Rain hours 4 a.m. to 4 p.m.		% Rain hours 4 p.m. to 4 a.m.	% Rain hours 4 a.m. to 4 p.m.		% Rain hours 4 p.m. to 4 a.m.	% Rain hours 4 a.m. to 4 p.m.	
1928	45.4	54.6	—	65.1	34.9	—	26.5	73.5	—
1929	50.4	49.6	—	80.9	19.1	—	31.4	68.6	—

* The indefinite column contains overlapping falls which could not be fairly allocated to either side.

From a study of these figures it will be seen that, with due regard to the lack of precise methods, the percentages reveal a striking similarity in each year. A deduction might be made that the variation in rainfall from year to year at any station is due to amount only, and that the type of fall and its percentage of the total is roughly a constant. It might be assumed that each station considered receives a definite proportion of its rainfall each year from each contributory source, viz., monsoon type and instability type. The actual amount of fall will depend on other conditions.

Monsoon Type.

Taking the two stations Accra and Asuansi, which are affected principally by the monsoon fall, it will be noted that :—

1. With equal distribution of rain hours, as at Accra, the chief weight of rain falls during Period A (4 p.m. to 4 a.m.).
2. With equal weight of rain, as at Asuansi, in each period the preponderance of rain hours is in Period B.

From this it may be assumed that, as far as monsoon rain is

concerned, this fall is heaviest at night, and that in the daytime the fall is much lighter in amount.

Instability Type.

The figures from Kumasi show a different relationship, and the percentage fall and the percentage rain hours are roughly equal in each case, being always greatest in Period A. It may be assumed, therefore, that the average rate of fall is equal in both periods.

Conclusions.

From the figures given, and from the fact that the monsoon weakens in power as it proceeds north, it may be assumed that the occurrence of rain will vary from morning in the south to evening in the north owing to the change in type from monsoon to instability rains.

A forecast, therefore, of the type and approximate time of average precipitation can be roughly determined by the geographical position of the station.

PAPER No. XLIV.

METEOROLOGICAL RECORDS IN THE GOLD COAST FOR 1929.

COMPILED BY J. M. ADAMS.

The records for 1929 are interesting in that the areas which received a heavier rainfall than usual were those in the North-West of the Northern Territories, the coastal area from Saltpond to Keta and the Western Province of Ashanti. The area round Kumasi and the South-West corner of the Colony, which are normally the areas of heaviest rainfall, received much less than usual. Five stations in the Kumasi district recorded their lowest totals.

Stations.

The following meteorological stations commenced recording during the year, viz., Takoradi and Salaga. Rainfall stations were opened at Enchi and Jema, and Wiawso station was reopened. Abra and Abetifi stations were closed.

Rainfall Records.

The highest monthly figures during the year were recorded at Half-Assini, 32.85 inches, Atwabo, 26.58 inches, and Axim, 25.39 inches—all in June. The heaviest fall in twenty-four hours was recorded at Keta on July 17th, when 7.50 inches fell. Other exceptionally heavy figures were at Cape Coast, 6.49 inches, on June 26th, and again at Keta, 6.45 inches, on June 16th.

The records for the year are given in Table IV, and the map at the end of this paper shows the mean annual distribution of rainfall for the whole country. The figures given at the side of the map are the annual means for each station, so that the figures for 1929 given in Table IV can be compared with them.

Temperature Records.

The mean temperature figures for each month and for the year are given for each station in Table II, together with the mean, maximum and minimum records.

The highest shade temperature of the year, 106°, was recorded at Tamale on March 6th, 7th and 8th. The lowest shade temperature was 50° at Akuse on February 4th. In the sun on February 20th and March 22nd at Tamale the mercury reached 167°. These figures

are lower than those recorded in 1928 and, as a whole, the means are also lower.

Relative Humidity.

The mean relative humidity for each month, and for the year for each station, is given in Table III. For the majority of stations these figures are slightly higher than those recorded in 1928.

Self-recording hygrometers for six stations were purchased, but had to be used for other work of an urgent nature.

It is hoped that self-recording instruments will be able to be placed at each station during next year, as the figures obtained from these instruments are of great importance and interest.

TABLE I

Stations Arranged in Order of Degrees of Wetness.

$$\frac{\text{Inches of Rain} \times \text{number of Rainy Days.}}{100}$$

1928		1929
Atwabo	163	—
—	142	Anyinam
—	131	Kibi
Abomposu	117	—
Dadiasu	116	Bunso
—	114	Atwabo
—	109	Mpraeso
—	108	Abomposu
Kintampo	105	Amedjofe
Tarkwa, Dentin	104	—
—	99	Kete-Kratchi
—	98	Mprim
—	96	Tarkwa
—	94	Jema
—	93	Nkawkaw
—	92	Honuta
Kibi	90	Juaso
—	89	Asamankese, Effiduasi
Butre (Seysie)	87	Mpayo
—	86	Dunkwa, Ejisu, Oda
Juaso	85	—
—	84	Begoro, Mansu, Agona
Half-Assini, Nkawkaw	82	Half-Assini, Kajebi
Oda	80	Akpafu
Kete-Kratchi	79	—
Mprim	77	Tafo
Kumasi	76	Dafo
—	75	Dadiasu
Agona	74	Koforidua, Kpeve, Kumasi
Mpraeso	73	—
Otikrom	72	—
Effiduasi	71	Dentin
Asamankese, Axim, Ejisu	70	Bekwai
Bekwai, Mampong (Ashanti), Esuasu	69	—
Dunkwa, Kpeve	68	—
Begoro	66	—
Akropong (Ashanti)	65	—
Mpennasa, Asuansi	64	Kpandu
Kodia-Kese	63	Kintampo, Angu
—	62	Wenchi, Asromaso, Asuansi
Ho, Koforidua	61	Butre (Seysie)
Bunso, Mansu	60	Axim, Kodia-Kese
—	59	Esuasu
Ejura, Goaso	58	—
Asromaso	57	Mpennasa
Sekondi, Wa	56	Mampong (Ashanti), Aburi
—	55	Tamale
Aburi	53	—
Bole, Dafo	52	Ejura
—	51	Akropong (Ashanti)
—	50	Apropong (Akwapim) Lawra
Tafo	49	—
Salaga, Wenchi, Akpafu	48	Wa
Sunyani, Angu	47	—
—	46	Salaga
—	44	Sunyani, Ho
—	43	Otikrom, Navrongo, Goaso, Kpeto
Akropong (Akwapim), Lawra	41	—
Kajebi	40	—
—	39	Sekondi
—	38	Yendi
Ajua, Navrongo, Tamale	34	—
Abra, Yendi	33	Accra, Odumase, Bawku, Ajua
—	31	Bole, Zuarungu
Gambaga	30	—
Otrokpe	29	—
Cape Coast	28	—
Akuse, Odumase	27	Djoje
Bawku	26	—
Mpayo, Zuarungu, Nsawam	25	Akuse
—	24	Otrokpe
Saltpond	23	Keta, Winneba
—	22	Achimota, Saltpond
—	18	Labadi
Accra	17	Nsawam
—	16	Cape Coast
Achimota	14	—
Keta	13	—
—	11	Gambaga
Labadi	10	—

TABLE II

TEMPERATURE RECORDS FOR THE YEAR ENDING DECEMBER 31ST, 1929.

Month.	Aburi.			Accra.			Achimota.			Akuse.			Asuansi.			Atwabo.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January ...	86.6	70.4	78.5	86.7	72.4	79.5	91.2	71.7	81.4	98.1	59.7	78.9	86.5	68.0	77.2	—	—	—
February ...	88.2	71.3	79.7	86.6	75.6	81.1	—	—	—	97.7	64.4	81.0	88.1	70.3	79.2	89.9	68.6	79.2
March ...	87.5	71.0	79.3	87.6	76.1	81.8	89.8	73.3	81.5	95.7	74.2	84.9	89.6	70.8	80.2	90.3	74.8	82.5
April ...	88.1	70.9	79.5	87.5	75.5	81.5	88.5	72.7	80.6	96.6	73.2	84.9	82.5	69.9	76.2	90.9	73.8	82.4
May ...	85.0	69.1	77.0	85.8	75.5	80.6	87.3	72.6	79.9	95.8	73.6	84.7	86.0	71.1	78.6	88.0	74.6	81.3
June ...	80.6	69.3	74.9	83.2	73.8	78.5	83.1	71.3	77.2	88.6	72.7	80.7	89.4	69.9	79.6	83.8	73.8	78.8
July ...	74.8	67.5	71.2	79.9	72.9	76.4	80.4	70.0	75.2	85.5	73.6	79.5	79.4	69.4	74.4	83.5	73.1	78.3
August ...	78.2	66.1	72.1	78.2	70.8	74.5	80.0	68.4	74.2	87.6	70.2	78.9	80.5	68.1	74.3	82.9	70.2	76.5
September ...	80.9	67.6	74.3	80.1	72.3	76.2	83.6	69.8	76.7	91.1	71.8	81.4	80.9	70.3	75.6	83.0	71.9	77.4
October ...	84.8	68.6	76.7	84.0	75.6	79.8	87.1	70.9	79.0	95.6	71.0	83.3	84.8	69.8	77.3	83.0	72.1	77.5
November ...	84.4	69.9	77.1	91.4	77.7	84.5	86.2	71.9	79.0	93.8	71.8	82.8	85.5	69.6	77.5	87.1	73.1	80.1
December ...	85.4	70.7	78.1	90.4	75.1	82.8	87.4	70.8	79.1	93.5	68.7	81.1	87.2	67.5	77.4	87.0	72.1	79.6
Mean ...	83.7	69.4	76.5	85.1	74.4	79.8	85.9	71.2	78.5	93.3	70.4	81.9	85.0	69.6	77.3	86.3	72.5	79.4

Month.	Axim.			Begoro.			Cape Coast.			Keta.			Kintampo.			Kpeve.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January ...	86.7	80.5	83.6	88.7	68.4	78.5	85.0	72.5	78.7	89.9	80.5	85.2	94.5	59.2	76.8	92.5	74.6	83.5
February ...	84.2	76.7	80.4	88.4	66.3	77.4	84.9	74.5	79.7	87.6	76.7	82.1	96.2	63.9	80.1	95.1	72.2	83.7
March ...	85.2	78.0	81.6	86.2	68.2	77.2	84.1	75.6	79.9	86.4	77.2	81.8	96.6	70.4	83.5	94.8	72.8	83.8
April ...	84.7	77.5	81.1	87.1	68.0	77.5	83.7	73.4	78.5	86.5	77.3	81.9	93.9	69.8	81.8	93.5	72.4	82.9
May ...	87.3	78.0	82.6	84.1	68.6	76.4	82.9	72.1	77.5	87.6	77.6	82.6	94.1	70.0	82.1	93.0	72.5	82.8
June ...	86.2	77.0	81.6	82.7	68.3	75.5	79.9	72.0	75.9	88.0	76.9	82.5	89.3	67.2	78.3	88.1	71.6	79.8
July ...	84.4	77.9	81.2	80.9	70.2	75.5	77.2	71.7	74.5	88.6	77.3	82.4	86.9	66.5	76.7	86.1	70.9	78.5
August ...	83.9	77.5	80.7	77.8	65.3	71.6	76.1	69.6	72.8	86.2	75.8	81.0	85.2	65.9	75.5	86.0	69.5	77.7
September ...	82.2	77.8	80.0	81.2	67.0	74.1	77.7	70.9	74.3	85.3	77.6	81.4	85.3	74.0	79.7	77.4	74.0	75.7
October ...	83.1	78.0	80.5	84.6	67.0	75.8	82.7	71.9	77.3	89.5	77.4	83.5	84.8	65.5	75.1	91.4	73.9	82.7
November ...	83.7	75.8	79.7	85.9	67.9	76.9	85.6	73.3	79.4	84.9	76.8	80.8	90.0	64.9	77.5	91.8	70.7	81.2
December ...	85.3	73.2	79.3	87.3	64.9	76.1	85.0	73.3	79.2	88.0	76.8	82.4	91.4	71.7	81.5	90.7	66.6	78.6
Mean ...	84.7	77.3	81.0	84.6	67.5	76.0	82.1	72.5	77.3	87.4	77.3	82.3	90.7	67.4	79.0	90.0	71.8	80.9

TABLE II (*Continued*).

TEMPERATURE RECORDS FOR THE YEAR ENDING DECEMBER 31ST, 1929.

Month.	Kumasi.			Sekondi.			Tamale.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
January	90.2	62.0	76.1	89.4	72.6	81.0	95.3	64.7	80.0
February	92.1	67.5	79.8	89.8	75.1	82.4	101.3	77.3	89.3
March	92.3	70.5	81.4	89.9	75.5	82.7	101.1	76.4	88.7
April	90.2	70.1	80.1	89.1	75.3	82.2	97.8	73.1	85.4
May	90.4	71.6	81.0	86.8	75.4	81.1	93.1	73.4	83.2
June	86.3	70.9	78.6	83.7	73.0	78.4	88.7	71.9	80.3
July	84.1	68.4	76.3	80.8	71.1	75.9	87.8	74.2	81.0
August	82.5	68.4	75.4	79.5	68.4	73.9	86.4	70.8	78 6
September ..	84.9	70.0	77.5	81.8	70.3	76.1	86.9	71.2	79.0
October	86.4	69.4	77.9	84.8	71.3	78.1	90.3	70.5	80.4
November ..	89.1	69.6	79.3	87.0	73.0	80.0	95.0	70.9	82.9
December ..	89.3	63.6	76.5	88.5	71.8	80.1	95.1	63.7	79.3
Mean	88.1	68.5	78.3	85.9	72.7	79.3	93.2	71.5	82.3

TABLE III.

Relative Humidity, 1929.

Month.	Aburi.	Accra.	Achimota.	Akuse.	Asuansi.	Atwabo.	Axim.	Begoro.	Cape Coast.	Keta.	Kintampo.	Kpeve.	Kumasi.	Sekondi.	Tamale.
January	75.1	69.2	77.6	—	85.9	84.1	64.2	83.8	75.8	64.2	84.0	70.1	79.0	81.0	32.2
February	85.4	72.1	—	66.6	82.1	83.4	89.2	84.7	83.6	77.1	82.3	69.3	81.3	80.7	47.4
March	85.4	70.9	70.4	69.6	76.9	79.2	84.4	83.1	83.2	67.8	67.9	71.5	82.3	76.1	56.0
April	81.3	71.3	67.9	68.3	77.6	77.8	89.3	85.5	77.4	64.1	69.3	73.1	84.6	73.5	60.1
May	89.2	76.8	68.8	67.2	79.8	81.5	87.2	87.0	84.1	65.1	72.1	76.0	82.8	75.6	71.2
June	89.6	79.0	80.0	76.5	87.1	88.1	89.1	87.1	88.5	63.8	81.7	84.5	87.3	83.1	75.9
July	93.4	81.6	82.0	73.3	87.1	83.5	91.5	86.8	86.3	60.8	82.0	81.8	87.0	82.6	78.1
August	87.1	84.1	78.8	70.3	85.4	85.0	90.0	89.8	87.5	73.8	83.9	81.1	87.5	83.1	76.9
September	95.6	81.9	75.0	72.1	86.3	87.3	89.2	91.2	86.2	85.1	80.4	79.9	88.0	85.0	80.4
October	90.5	71.0	65.0	64.2	83.5	86.4	90.8	90.9	83.0	81.6	77.5	69.7	88.5	81.9	71.8
November	87.0	70.5	75.2	69.3	84.3	84.2	90.8	87.2	89.3	81.8	66.4	75.2	89.3	84.3	62.8
December	81.8	73.5	74.0	76.3	86.8	84.4	90.5	84.4	87.3	78.1	64.6	76.7	85.8	84.5	35.7
Mean	86.8	75.2	74.0	70.3	83.5	83.7	87.2	86.8	84.3	71.9	76.0	75.7	85.3	80.9	62.4

TABLE IV

Summary of Rainfall in Inches for all Stations in the Gold Coast for the Year 1929.

Month.	Wiawso.	Kete-Kratchi.	Bogoro.	Esuasu.	Mpraeso.	Axim.	Jema.	Atwabo.	Mprim.	Half-Assini.	Bunso.	Dunkwa.	Amedjofe.	Honuta.	Kajebi.	Tafo.	Mpayo.	Anyinam.	Effiduasi.	Akpafu.	Tarkwa.	Juaso.
January	—	1.90	1.35	1.05	0.00	0.10	0.87	1.10	0.50	2.07	0.41	0.97	0.93	1.67	0.00	0.22	0.00	0.00	0.54	0.20	2.59	0.00
February	—	4.15	5.37	4.52	3.79	3.51	7.21	3.43	2.02	5.13	3.24	4.25	4.44	1.84	2.45	2.93	2.91	1.42	3.95	4.20	4.90	1.99
March	—	3.08	11.41	12.27	8.46	4.29	9.63	3.77	9.73	5.61	9.79	5.90	8.24	8.41	8.48	8.67	5.72	8.33	8.76	4.00	7.65	10.22
April	—	6.35	6.41	8.62	10.11	4.80	10.97	6.52	6.27	8.13	9.89	9.56	1.55	3.70	6.34	3.56	5.14	9.71	6.82	4.87	7.15	5.90
May	18.94	2.20	8.65	6.43	6.31	16.68	6.10	13.34	7.14	15.10	6.94	5.46	7.74	8.45	6.13	5.02	3.70	5.57	4.69	4.58	6.81	3.47
June	33.55	16.40	9.81	10.84	11.49	25.39	20.30	26.58	10.29	32.85	12.81	14.55	12.45	13.71	10.99	11.59	9.85	7.39	6.87	11.00	9.91	6.53
July	11.05	12.94	12.04	4.06	9.78	3.60	4.37	3.33	7.08	2.43	9.11	6.33	7.92	9.11	4.18	11.85	7.26	7.66	5.39	2.57	3.41	11.73
August	5.40	12.07	4.48	1.58	4.56	1.30	1.85	0.58	2.42	0.45	4.66	2.06	12.40	7.49	10.43	7.20	9.75	6.33	1.50	7.66	1.85	2.93
September	16.79	18.16	7.18	5.52	7.57	3.75	3.49	2.88	6.89	2.13	4.85	6.76	8.26	7.44	5.34	2.97	15.21	4.95	6.64	11.59	3.25	7.42
October	8.93	15.29	8.76	12.25	12.80	0.75	2.77	4.42	10.84	2.25	4.74	3.49	5.95	2.12	9.23	7.44	6.26	7.01	10.57	16.13	4.78	7.29
November...	17.73	7.41	8.04	12.79	5.01	11.30	10.26	4.52	10.03	6.39	4.08	12.52	2.38	3.66	5.14	5.07	2.48	8.30	10.95	4.74	11.32	6.75
December	0.37	0.00	1.01	3.01	1.92	1.96	2.55	4.81	0.00	0.48	2.34	0.41	0.00	2.00	0.00	1.78	0.00	0.90	0.00	2.06	1.39	0.26
Total...	(a) 112.76	99.95	84.56	82.94	81.80	77.43	75.37	75.28	74.21	73.02	72.86	72.26	72.26	69.60	68.71	68.30	68.28	67.57	66.68	73.60	65.01	64.49
Number of rainy days (0.01 inch or more) ...	123	99	99	71	133	78	125	151	132	112	160	119	154	133	119	113	127	212	134	109	148	140
Highest previous rainfall...	73.14	66.59	72.86	102.63	85.26	109.65	—	105.72	67.59	88.77	—	77.91	—	—	—	62.83	—	95.07	66.16	—	57.21	76.12
Lowest previous rainfall ...	40.14	43.61	50.43	70.66	57.55	47.64	—	79.02	66.82	61.63	—	45.55	—	—	—	58.70	—	40.27	65.02	—	29.08	53.42

(a) 8 months' record.

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1929 (*Continued*).

Month.	Nkawkaw.	Dentin.	Kibi.	Ejisu.	Abomposu.	Kintampo.	Oda.	Salaga.	Mpennasa.	Mansu.	Sunyani.	Wenchi.	Dadiasu.	Agona.	Mampong (Ash.).	Koforidua.	Asamankese.	Kpandu.	Kumasi.	Angu.	Ejura.	Lawra.
January	0.00	2.30	0.39	1.18	0.05	0.00	1.05	0.00	2.55	1.29	0.00	0.80	0.00	1.36	1.17	3.17	2.19	0.70	0.65	1.19	0.37	0.00
February	1.02	3.00	5.09	1.23	1.99	2.74	3.55	0.41	2.34	4.64	1.44	1.06	4.00	3.79	1.78	2.07	2.26	3.40	0.88	1.52	2.90	0.00
March	3.85	9.00	6.89	12.22	8.15	5.09	10.19	5.55	2.34	5.93	7.72	3.64	9.58	6.42	8.51	8.85	9.46	7.52	8.68	3.01	6.17	1.09
April	8.45	3.46	5.17	6.06	6.44	5.33	5.61	6.37	2.78	4.49	2.48	4.14	4.86	4.92	5.23	4.70	7.50	5.27	4.07	5.79	3.80	0.98
May	5.26	7.02	4.90	5.18	4.05	4.71	5.30	3.80	11.41	6.56	4.58	11.75	2.33	4.02	3.29	3.43	8.04	4.03	3.62	10.68	6.92	7.85
June	8.69	11.95	13.32	9.83	9.01	17.48	8.79	13.78	21.49	10.97	14.03	16.77	10.60	8.90	10.61	8.68	5.46	5.57	12.18	10.06	7.42	9.55
July	8.04	8.32	6.70	3.94	5.05	5.40	5.24	5.68	6.64	5.65	9.29	7.35	7.83	6.35	2.81	4.74	6.18	4.82	2.78	4.25	5.60	10.43
August	7.01	4.04	2.97	2.55	5.25	1.50	2.78	5.52	2.13	2.93	1.49	0.91	2.02	3.10	1.79	4.83	2.50	7.30	0.93	3.97	0.96	10.87
September	6.27	5.95	5.34	4.64	5.01	11.78	6.03	11.07	3.87	7.40	8.89	5.35	5.49	5.91	7.23	5.94	2.51	5.52	5.82	6.90	10.31	10.42
October	8.52	5.13	7.33	9.49	6.01	5.45	5.64	8.77	1.26	4.16	7.84	6.86	6.98	7.22	11.07	7.26	3.30	7.22	10.67	5.57	7.24	4.09
November...	4.88	4.10	4.23	6.26	9.52	2.71	6.31	0.25	3.59	4.79	2.91	1.57	5.02	7.23	5.47	3.45	5.85	6.34	6.89	2.63	5.33	1.06
December	2.43	0.12	1.83	0.77	1.48	0.00	1.69	0.00	0.72	1.96	0.00	0.00	0.87	0.00	0.00	1.23	2.75	0.10	0.46	1.46	0.00	0.00
Total	64.40	64.39	64.16	63.35	63.01	62.19	62.18	61.20	61.12	60.77	60.67	60.20	59.58	59.22	58.86	58.35	58.00	57.79	57.63	57.03	57.02	56.34
Number of rainy days (0.01 inch or more) ...	144	110	204	135	171	101	139	76	94	138	74	10.3	152	142	96	127	154	111	128	111	92	88
Highest previous rainfall...	68.51	91.04	79.90	64.45	74.68	100.58	83.75	64.52	75.72	83.70	69.47	60.95	69.47	77.10	59.96	59.50	77.47	—	70.40	54.22	80.75	53.50
Lowest previous rainfall ...	60.68	82.22	45.77	56.90	51.36	48.87	43.61	37.79	54.99	46.90	41.30	53.40	41.30	60.34	52.51	44.94	50.40	—	40.07	49.58	47.45	36.43

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1929 (*Continued*).

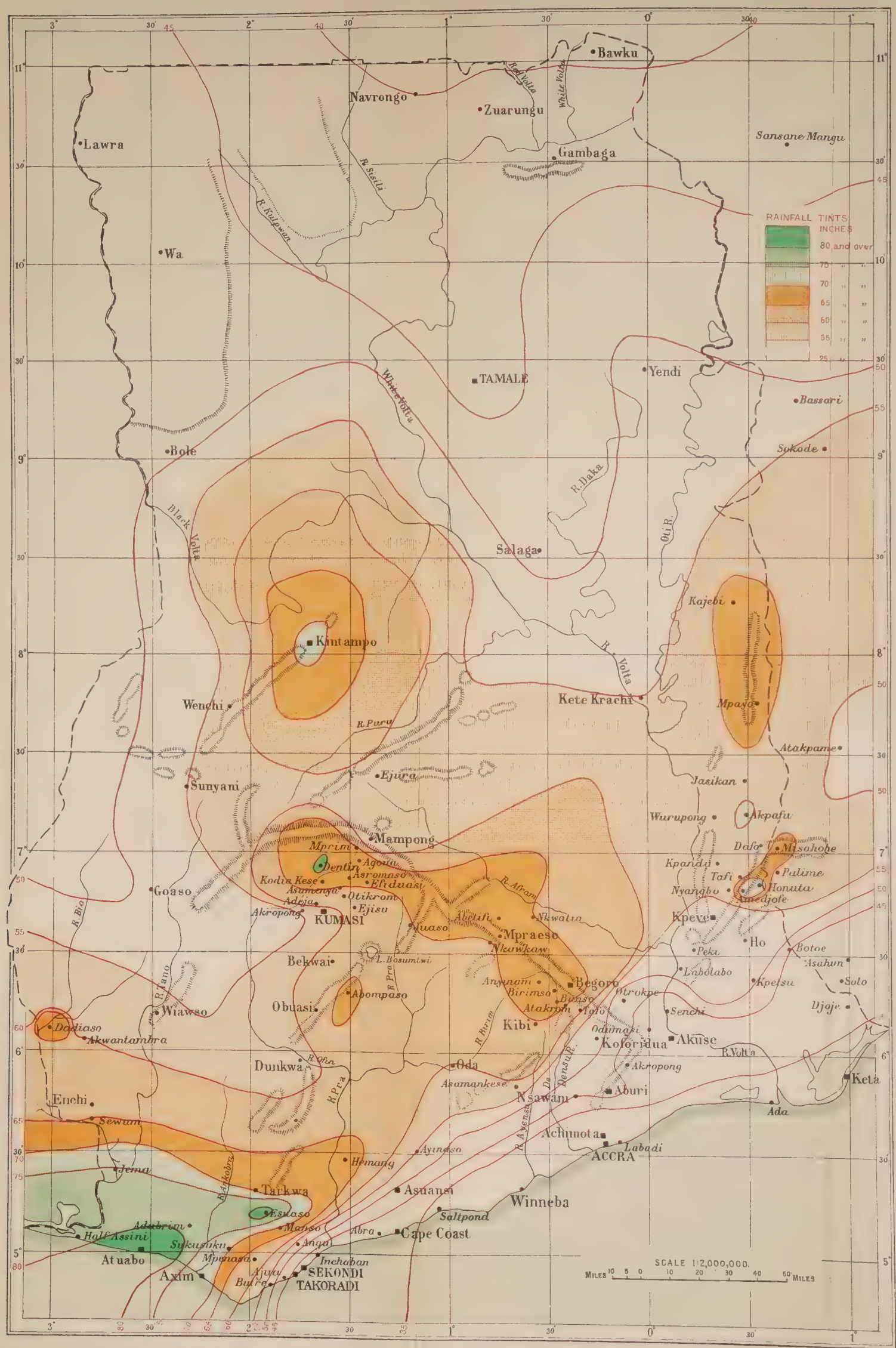
Month.	Otikrom.	Kodia-Kese.	Dafo.	Akropong (Ash.).	Bekwai.	Butre (Seysie).	Kpeve.	Asromaso.	Goaso.	Wa.	Tamale.	Keta.	Navrongo.	Zuarungu.	Otrokpe.	Yendi.	Kpetoe.	Ho.	Ajua.	Odumase.	Aburi.	Akropong (Akwapim).
January	0.95	0.98	0.04	1.92	0.00	1.18	0.32	1.16	0.65	0.00	0.00	0.00	0.00	0.00	1.79	0.00	2.02	0.52	0.00	0.54	0.96	0.83
February	1.94	3.67	2.43	3.52	1.80	1.62	2.44	4.40	1.16	0.17	0.53	0.20	0.00	0.00	2.47	0.08	1.51	1.83	0.30	1.73	2.87	3.28
March	9.98	6.12	6.01	6.57	7.39	1.91	7.71	6.05	4.01	3.32	0.84	1.48	0.24	0.15	7.84	1.41	6.25	5.70	2.10	9.21	3.64	3.53
April	4.49	5.83	2.88	3.26	3.95	4.25	3.91	2.88	4.23	1.93	3.42	5.69	1.37	2.56	5.95	1.67	2.83	4.33	2.67	2.24	3.65	1.76
May	4.52	3.98	5.37	3.12	4.91	9.63	6.01	6.17	6.31	5.03	8.25	5.90	7.94	4.85	5.08	5.08	5.18	3.69	7.31	2.22	3.42	2.42
June	7.62	9.47	10.84	8.44	6.54	15.82	6.66	6.33	13.36	11.49	2.82	20.32	4.70	4.14	6.24	5.28	7.57	8.73	11.08	8.37	7.44	6.83
July	3.57	3.25	6.27	5.50	3.73	5.20	4.47	2.69	3.85	4.19	8.84	9.42	9.07	3.87	2.00	6.12	5.69	3.98	4.76	1.51	3.66	3.78
August	2.49	1.79	7.43	0.91	1.02	2.52	12.90	1.44	2.22	9.29	5.86	0.55	11.81	14.79	1.35	3.84	3.79	4.65	1.95	1.24	4.12	2.34
September...	3.97	7.12	7.32	6.63	2.43	3.97	2.40	4.19	2.77	12.91	11.75	1.82	8.35	8.61	4.39	11.42	4.10	3.03	3.67	2.00	2.78	2.79
October	8.24	6.07	3.55	6.62	9.97	3.29	1.55	6.59	6.11	3.32	7.30	0.97	2.30	6.63	6.55	9.80	3.42	2.59	3.99	8.95	4.49	10.04
November...	8.42	7.14	3.13	8.56	9.60	2.79	4.58	11.12	7.64	0.35	1.65	1.88	0.17	0.00	1.90	0.63	1.82	4.75	4.76	2.53	3.76	1.97
December	0.00	0.00	0.00	0.00	2.94	1.27	0.20	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.00	0.00	0.83	0.31	0.94	2.55	2.00	2.80
Total...	56.19	55.38	55.27	55.05	54.28	53.45	53.15	53.02	52.31	52.00	51.26	48.88	45.95	45.70	45.56	45.33	45.01	44.11	43.53	43.09	42.79	42.37
Number of rainy days (0.01 inch or more) ...	94	108	137	92	129	114	140	116	82	93	108	47	93	68	54	83	95	99	75	77	130	118
Highest previous rainfall...	77.72	85.83	—	58.23	104.90	75.47	53.65	68.36	59.50	57.21	61.77	51.44	43.29	51.62	—	67.12	—	60.52	49.54	49.77	73.16	47.38
Lowest previous rainfall...	55.48	61.53	—	—	46.21	51.76	49.80	54.53	44.94	29.08	32.36	13.88	28.66	37.93	—	43.92	—	48.38	36.81	37.10	32.09	29.01

SUMMARY OF RAINFALL IN INCHES FOR ALL STATIONS IN THE GOLD COAST FOR THE YEAR 1929 (*Continued*).

Month.	Asuansi.	Djoje.	Takoradi.	Sekondi.	Bawku.	Akuse.	Enchi.	Saltpond.	Bole.	Accra.	Nsawam.	Achimota.	Winneba.	Labadi.	Abra.	Cape Coast.	Gambaga.
January	1.90	0.01	—	0.00	0.00	0.53	—	0.00	0.00	0.26	1.60	1.90	0.47	0.18	0.36	0.34	0.00
February	1.06	1.47	—	0.53	0.00	3.01	—	0.00	0.45	1.08	1.65	1.32	0.28	0.05	0.01	0.00	0.00
March	3.33	1.61	—	3.22	2.15	5.59	—	5.58	2.48	2.97	6.15	2.24	1.47	1.97	3.35	1.82	0.04
April	4.30	3.92	—	3.99	1.74	3.41	—	2.94	2.88	3.13	2.91	5.14	5.42	2.72	2.59	1.48	0.61
May	4.81	3.14	2.82	5.01	6.35	2.62	—	10.46	4.72	4.67	4.49	3.56	6.23	3.36	4.49	5.43	2.30
June	8.01	16.51	11.60	10.31	5.55	12.09	14.69	8.73	6.16	12.71	3.99	7.29	12.22	14.03	15.10	16.37	2.92
July	5.47	3.14	7.68	3.77	4.64	0.93	4.50	1.30	2.13	2.34	4.18	3.39	0.90	2.29	3.45	0.35	6.66
August	2.26	0.72	1.08	1.02	8.00	3.74	1.04	2.81	2.49	1.14	1.67	2.37	1.18	0.75	0.59	0.04	3.76
September	2.48	0.52	3.30	2.01	8.79	0.54	9.40	0.80	8.81	0.28	0.56	0.02	0.22	0.28	1.27	0.75	2.76
October	3.54	2.57	0.64	3.99	2.74	1.62	2.42	2.40	4.13	3.37	2.66	2.10	1.03	2.49	0.34	1.52	0.86
November	2.95	5.63	10.52	4.77	0.29	3.15	4.51	1.19	3.06	1.17	4.49	2.44	1.73	1.01	—	1.30	0.00
December	1.97	2.36	2.03	1.73	0.00	2.54	1.75	1.27	0.00	2.74	1.35	3.54	2.33	1.70	—	0.96	0.00
Total	42.08	41.60	40.47	40.35	40.25	39.77	38.31	37.48	37.31	35.86	35.70	35.32	33.48	30.83	30.54	30.36	19.91
Number of rainy days (0.01 inch or more)	147	65	96	98	81	62	58	58	84	90	49	62	69	57	77	54	58
Highest previous rainfall	74.17	—	—	57.76	39.77	58.98	—	43.80	54.62	44.20	55.40	28.54	44.27	36.87	35.78	56.25	56.47
Lowest previous rainfall	35.62	—	—	32.98	38.29	35.14	—	19.73	53.64	10.84	39.33	21.09	14.60	10.78	25.20	30.19	34.75

DEPARTMENT OF AGRICULTURE.

Mean Distribution of Rainfall
(to the end of 1929)



SURVEY H.Q. ACCRA, 1930.

List of Rainfall Recording Stations.

	Name.	Amount. Inches.	No. of years of record.
1.	Abetifi	(42.99)	10 months
2.	Abomposu	67.55	17 years
3.	Abra	33.02	7 "
4.	Aburi	47.59	39 "
5.	Accra	27.63	43 "
6.	Achimota	27.15	5 "
7.	Ada	32.05	7 "
8.	Adeja	70.65	1 year
9.	Adubrim	68.46	3 years
10.	Agona	65.95	4 "
11.	Ajua	45.21	10 "
12.	Akpafu	73.60	1 year
13.	Akropong (Akwapim)	39.59	3 years
14.	Akropong (Ashanti) ...	55.05	1 year
15.	Akuse	41.22	15 years
16.	Akwantambra	60.00	—
17.	Amedjofe	72.26	1 year
18.	Angu	53.45	4 years
19.	Anyinam	65.80	22 years
20.	Asamankese	59.58	7 "
21.	Asromaso	54.30	3 "
22.	Asuansi	49.59	21 "
23.	Asumenya	(34.88)	6 months
24.	Atakrom	69.69	5 years
25.	Atwabo	86.67	3 "
26.	Axim	76.69	15 "
27.	Ayinasu	55.17	7 "
28.	Bawku	39.30	3 "
29.	Begoro	69.77	8 "
30.	Bekwai	62.70	16 "
31.	Birimso	70.45	13 "
32.	Bole	48.52	2 "
33.	Botoe	45.01	1 years
34.	Bunso	67.08	9 years
35.	Butre (Seysie)	53.52	9 "
36.	Cape Coast	38.19	7 "
37.	Dadiasu	65.16	8 "
38.	Dafo	55.27	1 year
39.	Dentin	79.22	2 years
40.	Djoje	41.60	1 year
41.	Dunkwa	57.44	15 years
42.	Efiduasi	65.95	3 "
43.	Ejisu	62.17	4 "
44.	Ejura	57.54	14 "
45.	Enchi	(38.31)	7 months
46.	Esuaso	82.33	4 years
47.	Gambaga	42.99	5 "
48.	Goaso	51.23	6 "
49.	Half-Assini	76.58	8 "
50.	Hemang	67.08	10 "
51.	Ho	54.83	8 "
52.	Honuta	69.60	1 year
53.	Inchaban	41.38	1 year
54.	Jema	75.37	1 "
55.	Juaso	65.42	14 years
56.	Kajebi	68.71	1 year
57.	Keta	27.67	24 years
58.	Kete-Krachi	55.25	11 "
59.	Kibi	63.99	17 "
60.	Kintampo	70.59	15 years
61.	Kodia-Kese	67.23	4 "
62.	Koforidua	52.09	8 "
63.	Kpandu	52.13	10 "
64.	Kpetsu	52.38	4 "
65.	Kpeve	52.20	3 "
66.	Kumasi	58.49	23 "
67.	Labadi	25.17	7 "
68.	Labolabo	50.81	8 "
69.	Lawra	49.06	4 "
70.	Mampong (Ashanti) ...	56.94	4 "
71.	Mansu	69.82	16 "
72.	Mpayo	68.28	1 year
73.	Mpenasa	62.22	5 years
74.	Mpraeso...	68.54	12 "
75.	Mprim	68.96	4 years
76.	Navrongo	40.02	4 "
77.	Nkawkaw	64.58	4 "
78.	Nkwatia	65.00	10 "
79.	Nsawam	44.86	4 "
80.	Obuasi	62.03	4 "
81.	Oda	60.17	15 "
82.	Odumasi	38.11	5 "
83.	Otikrom	62.19	4 "
84.	Otrokpe	45.56	1 year
85.	Peki-Blengo	52.09	13 years
86.	Salaga	51.19	15 "
87.	Saltpond	32.14	15 "
88.	Sekondi	40.61	26 "
89.	Senchi	40.00	—
90.	Sukusuku	70.00	—
91.	Sunyani	54.57	15 years
92.	Tafo	63.05	4 "
93.	Takoradi	(40.47)	8 months
94.	Tamale	42.55	20 years
95.	Tarkwa	68.15	26 "
96.	Wa	47.00	13 "
97.	Wenchi	55.69	8 "
98.	Wiawso	56.99	12 "
99.	Winneba	28.61	8 "
100.	Yendi	52.11	8 "
101.	Zuarungu	43.34	12 "

GERMAN FIGURES.

1.	Asahun	45.16	6 years
2.	Atakpame	53.46	9 "
3.	Bassari	51.20	—
4.	Jasikan	53.57	6 years
5.	Palime	58.37	6 "
6.	Misahohe	65.38	9 "
7.	Nyangbo	56.26	8 "
8.	Sansane-Mangu ...	42.20	—
9.	Sokode	52.03	9 years
10.	Solo	43.80	9 "
11.	Tafi	55.49	9 "
12.	Wurupong	54.02	1 year